Excavation and Embankment

Georgia Department of Transportation

FORWARD

The area of excavation and embankment inspection has become a complex task. An inspector should be familiar with all equipment, testing, and work procedures utilized during this phase of construction. If the embankment and foundation of a roadway are not properly constructed, only poor performance can be expected from any surface pavement. Therefore, an inspector must be able to make accurate decisions in the field while construction is in progress. This study course is designed to provide the background knowledge which, coupled with experience, will prepare the inspector of excavation and embankment to perform his/her duties.

By providing you with the excavation and embankment information, this course will periodically test your recall on that information. This method reinforces what you have just read - enabling you to retain the information longer than by traditional methods of instruction such as lecture and text book.

TO THE STUDENT

To get the most from this course, start at the beginning. Read each section as it comes; preparing you for the next section. To make reading easier, the information is divided into frames. At the end of some frames, you will find questions. By answering these questions, you will be able to retain what you have just read longer than by lecture or discussion.

The answers to these questions are as follows: If the questions are on an odd page, look on the following odd page. If the questions are on an even page, turn that page back and look at the preceding even page. To explain further, the answers to questions on page four can be found on page two.

TABLE OF CONTENTS

CHAPTER 4

Sequence of Operations
Equipment
Clearing and Grubbing
Georgia Air Control Regulations
Ground Preparations
Fills
Testing and Grade Checking
Cuts
Review Questions

CHAPTER 5

Special Construction
Muck Excavation
Undercutting
Embankments Constructed Without Density Control
Hydraulic Embankment
Lime Treatment
Review Questions

CHAPTER 6

Documentation
Source Documents
Inspector’s Reports
Inspector’s Diaries
Load Tickets

CHAPTER I

Introduction to the Roadway

1-1. embankment

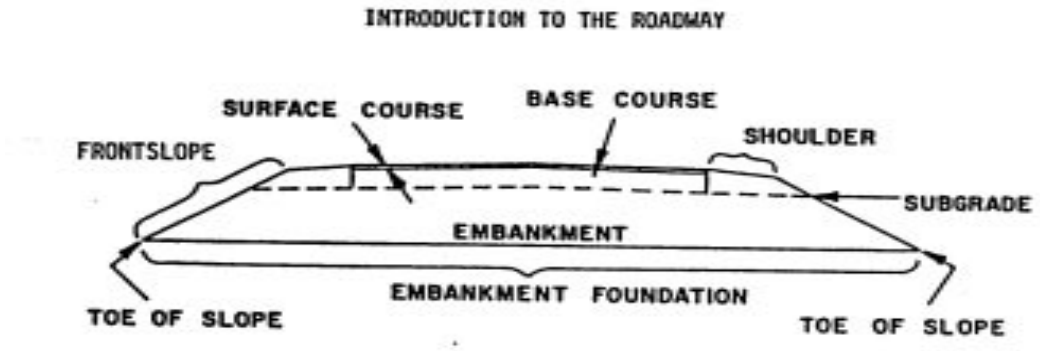
1-2. embankment foundation

1-3. frontslopes

1-4. toe

1-5. top of backslope

1-6. ditches

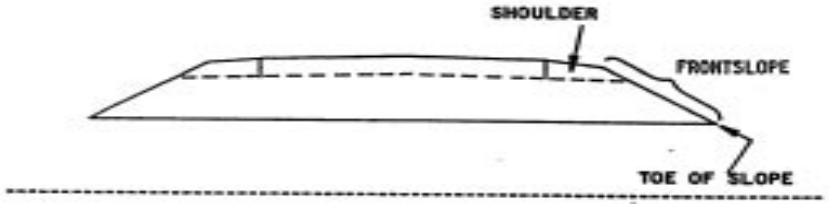


The above diagram is a cross section of a roadway. After the natural ground has been properly prepared, it becomes the embankment foundation. The embankment foundation is the support surface on which the embankment is constructed. Also an inspector must recognize drainage patterns which require special types of construction control measures. An inspector should study and know the topography (land configuration) of the project.

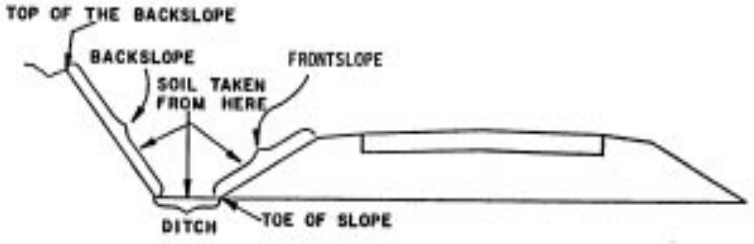
The embankment consists of soil that is placed on the embankment foundation in order to raise the level of the roadway to the correct grade and to provide adequate support for the layers of base and surface courses that make up the roadway.

Since the embankment foundation and embankment provide the basic support of the entire roadway, it is very important that they be properly constructed in accordance with all plans and specifications. Grades, slopes, density, and all other controls must be accurately monitored.

The frontslopes are the side slopes of the roadway between the edges of the shoulder and the existing ground. The point where the frontslope meets the existing ground is called the toe of the slope.



The soils used for constructing the embankment are taken from the surrounding area whenever possible. The excavation of these soils from the sides of the construction area creates side ditches for roadway drainage.



Such excavation normally begins where the backslope meets the existing ground line. This point is known as the top of the backslope.

REVIEW QUESTIONS

Fill in the blanks for each of the following statements.

1-1 The soils placed between the embankment foundation and the subgrade surface form the _____.

1-2 The support surface on which the embankment is constructed is the _____.

1-3 The side slopes of the roadway between the shoulder edge and the existing ground are called _____.

1-4 The point where the frontslope joins the existing ground is known as the _____ of the slope.

1-5 The point where the backslope meets the existing groundline is known as the _____.

1-6 Excavation for embankment material from the surrounding area creates side _____ for roadway drainage.

Besides understanding the structure of the roadway, familiarity with soil types and the characteristics of each is important during this phase of construction, because soil type often determines the type of treatment that may be necessary to properly build the embankment.

FILL IN THE BLANKS:

1-7 An Inspector must be able to recognize different types of _____ that are encountered in embankment construction.

1-8 In order to recognize drainage patterns and the need for special types of construction or erosion control measures, the Inspector needs to be able to understand the _____ of the construction area.

1-9 In order to be sure that all materials and work meet Department Specifications, the Inspector must be able to accurately take _____ and perform all required _____.

1-10 All Department forms, such as daily reports, test reports, and field books must be maintained by the _____.

CHAPTER II

Embankment Materials/Borrow Pits

Embankments are made up of soils that are excavated from areas inside or outside of the right-of-way. Soils excavated from within the right-of-way are referred to as unclassified excavation; soils brought in from other sources are called borrow material.

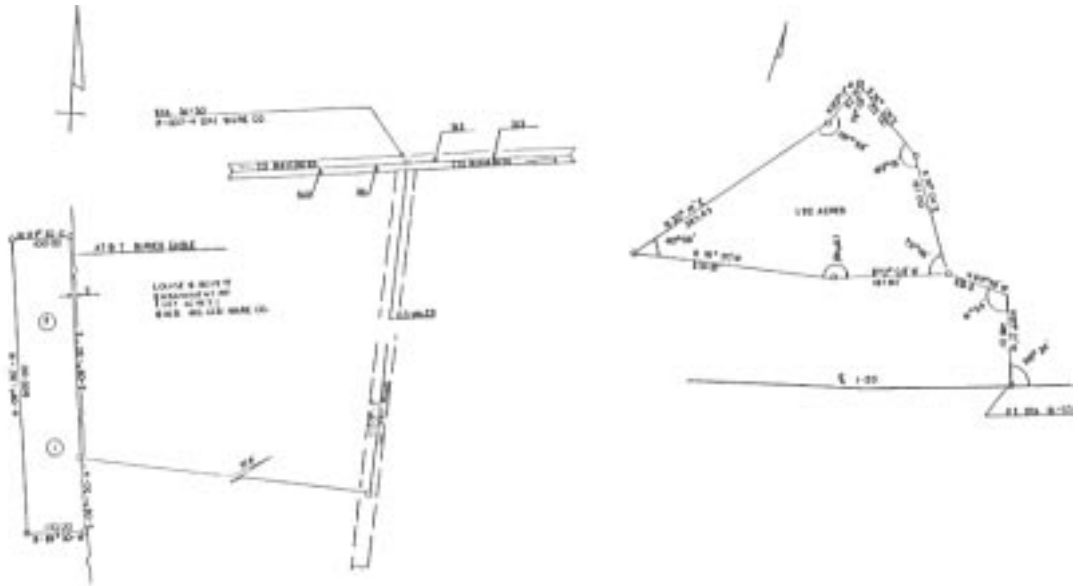
Borrow material is excavated from areas known as borrow pits. It is the contractor's responsibility to acquire the land for his borrow pits, unless the Department obtains the pit. The District Materials Engineer must approve this pit and all environmental clearances gotten prior to any material being used from it. Laboratory crews may sample the pit and test the materials, as well. All results will then be transmitted to the Project Engineer for his project files.

So that the borrow material can be tested and classified before being placed in the embankment, a pit sketch and sampling request must be submitted to the District Materials Engineer. After the laboratory crew samples the pit and tests the material, the results are transmitted to the Project Engineer for his project files.

The following drawing is an example of a properly completed pit sketch for a pit referenced to the centerline of the project.

Note the inclusion of the North Arrow for direction, Station numbers, distances, measurements, and angles.

Department Furnished Pit



2-1. unclassified excavation

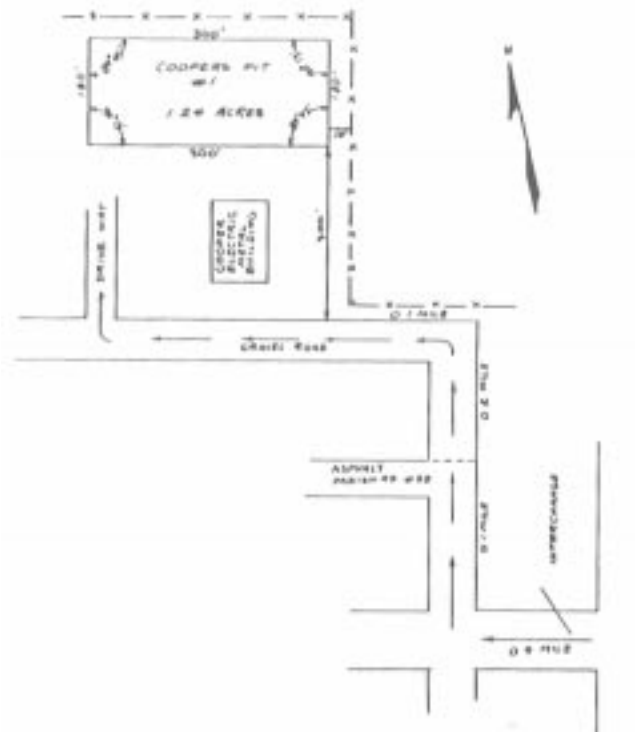
2-2. borrow

2-3. reference to centerline/directional arrows

The following sketch is an example of the boring diagram that would be returned to the Project Engineer from the District Laboratory.

This sketch is an example of a borrow pit that is not located near the project; it must however, be referenced to the project centerline.

Careful directions must be given to enable the boring crew and contractor to easily locate the pit. Again, note distances, measurements, angles, and North Arrow.



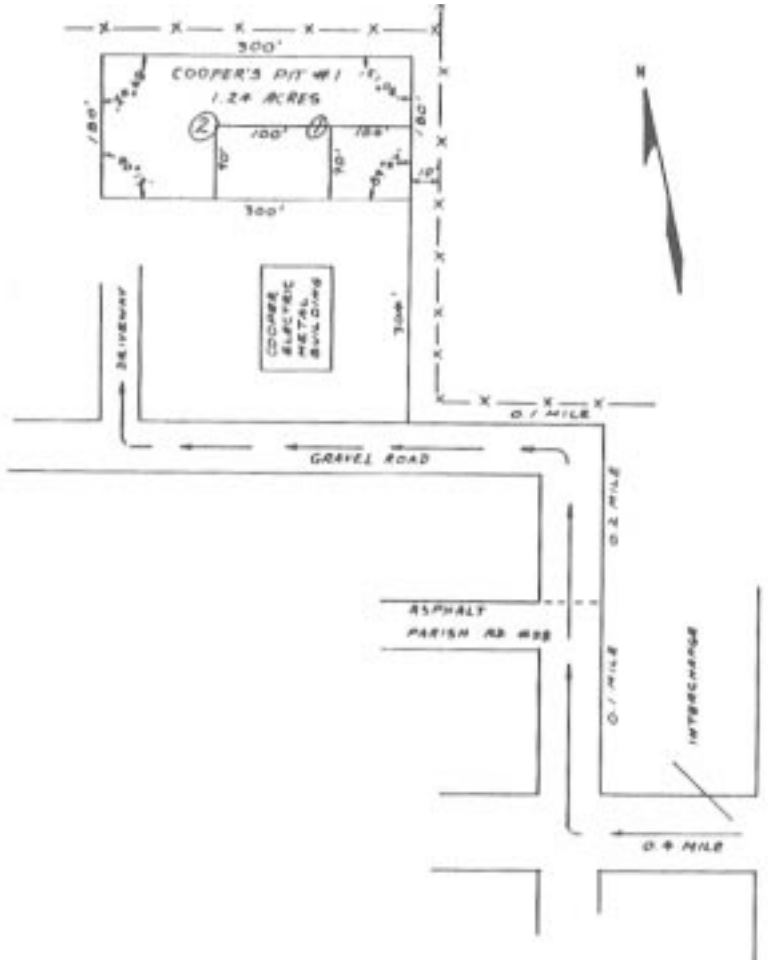
1-7. soil

1-8. topography (land configuration)

1-9. samples/tests

1-10. Inspector

The following sketch shows the boring diagram for the pit depicted previously.



CIRCLE THE CORRECT ANSWER.

2-1 Material excavated from within the right-of–way is called (unclassified excavation / borrow).

2-2 Soil brought to the roadway from sources outside the right-of-way is called (borrow / classified excavation).

2-3 List the pertinent information that should be included on a borrow pit sketch.

_____

Project personnel should visually observe fill material periodically being placed in the embankment for any archeological, historical, and paleontological artifacts.

Should the contractor or the project engineer notice any artifacts during construction, Project personnel should call a halt to operations in the immediate area of the findings. The Department's Environmental Section should be notified immediately upon any of these findings. The project engineer should be notified also.

Soils and their Characteristics

An inspector needs to understand some basic information about soils. He needs to know the basic characteristics of the soil with which he is working. The laboratory will identify the soil types from their tests. Other information about soils in the construction zone may be found in the soil survey.

The following information will be given when soil surveys are performed.

- Gradation
- Maximum Dry Density
- Optimum Moisture
- Volume Change
- Atterberg Limits
- GDOT Soil Classification
- AASHTO Soil Classification
- Location of Borings
- Depth of Borings

ATTERBERG LIMITS =	**PLASTIC LIMIT** **LIQUID LIMIT** **PLASTICITY INDEX**

The term Atterberg Limits refers to the Plastic Limit (P.L.), the Liquid Limit (L.L.), and the Plasticity Index (P.I.) of a soil.

The Plastic Limit (P.L.) is the minimum moisture content at which the soil begins to react as a plastic. Simply stated, it is that when enough moisture is present for the soil to be shaped, but not so wet that it loses its shape after it is worked.

The Liquid Limit (L.L.) is the moisture content at which a soil passes from the plastic to the liquid state. It is the minimum moisture content at which a soil will flow if jarred slightly. If the soil is at its "liquid limit" it will appear unstable under vibratory compaction equipment. In other words, it will appear to be a liquid.

The Plasticity Index (P.I.) is a calculated value for the range of moisture content in which a soil may exist in a plastic condition. To calculate this value, the Plastic Limit is subtracted from the Liquid Limit. Construction inspectors rarely need this information to perform their duties. However, the ability to recognize that a soil has limitations when exposed to moisture is very important.

$$P.I. = L.L. - P.L.$$

There are some soils that are non-plastic. A non-plastic soil is one for which the Plastic Limit and Liquid Limit cannot be found, or for which the P.L. and L.L. are equal. Meaning, the moisture content is crucial to achieving compaction and stability.

In the field, in order to tell if a soil is plastic or not, roll it into threads to see if it will crumble. If it doesn't crumble easily, it is plastic. This easy field test will let you know that working at or near the soil's optimum moisture content will give the best results for embankment construction.

ANSWER THE FOLLOWING QUESTIONS.

2-4 Where will information about the soils in the construction area and borrow pit area be found?

_____

2-5 List 9 basic areas of information that will be provided about soils.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

2-6 What three soil characteristics are referred to as Atterberg Limits?

a. _____

b. _____

c. _____

2-7 What is the formula for finding the Plasticity Index?

_____

2-8 What is a non-plastic soil? _____

2-9 How can you recognize a plastic soil in the field?

_____

The gradation analysis is part of the information given on the soil survey sheets in the plans. Gradation analysis is a classification of soils based on particle sizes.

The soils are divided into four groups:

Gravel
Sand (coarse and fine)
Silt
Clay

Sand and gravel are coarse-grained particles that do not stick together.

Silt particles do not stick together well and have a low to medium plasticity.

Clay particles are highly plastic and tend to stick together.

While it is easy to identify sand or gravel under field conditions, it is more difficult to distinguish between silt and clay. Soil test results should always be consulted for certain identification.

2-10.
a. gravel
b. sand
3. silt

Each soil type has individual characteristics. For example, sand and gravel are both highly stable in roads, are easily penetrated by water, but drain easily.

2-11. clay

Sand is a highly erodible material. The slopes of a sand embankment will tend to shift and wash. In order to prevent such erosion, the sand must be confined or held in place by a plastic soil such as clay. This procedure is sometimes referred to as “wrapping” or using a “clay blanket.”

2-12. silt

2-13. sand

Silt also erodes easily and is highly unstable. In order to work with silt, it is critical that the material be maintained at optimum moisture content. Because silt is so unstable, silty soils are not normally used in embankments; however, should they be used, the silty material must be confined with a plastic material.

Clay soils tend to have a high Liquid Limit, because clay has a strong attraction for water. When clay soils are wet, they expand or swell. Care must be exercised in compacting these soils. If they are over-compacted, they will shrink; hence, when water enters the material the swell potential is increased. When clay soils swell after a roadway has been completed, the increased volume of the embankment can be reflected in surface failures.

ROADWAY MATERIALS

Materials for roadway construction shall not contain any logs, stumps, sod, weeds, or other perishable matter, the Standard Specifications states. They are divided into six major classes and Classes I, II, and III are further subdivided and are identified by description and physical property requirements as specified by Table 810.01 of the Standard Specifications.

CLASSES

Class I Consists of well-graded, angular sands and friable clays.

Class II Consists of well to poorly graded sands and clay soils with low volume change properties.

Class III Consists of low density, poorly graded sands, clay soils with high plasticity and volume change properties; disintegrated rock which is easily broken down during manipulation, and low density inorganic soils.

Class IV Consists of highly organic soils or peat muck and other unsatisfactory soils generally found in marshy/swampy areas.

Class V Consists of shaly materials that are not only finely laminated but have detrimental weathering properties and tend to disintegrate.

Class VI Consists of rock or boulders that cannot be readily incorporated into the embankment by layer construction.

2-4. lab test reports and soil surveys

2-5.
a. gradiation
b. max dry density
c. optimum moisture
d. volume change
e. Atterburg limits
f. GDOT soil classification
g. AASHTO soil class
h. location of borings
i. Department of borings

2-6.
a. plastic limit
b. liquid limit
c. plasticity inder

2-7. PI=LL-PL

2-8. One for which the PL and the LL can not be found, orthey are equal

2-9. Roll it to see if it does not crumble easily

Clay
11. swells when wet
12. highly plastic
13. strong when dry
14. high liquid limit

Gravel
15. easily penetrated
16. drains well
17. stable

TABLE 810.01 PHYSICAL PROPERTIES (Subdivisions of Classes I, II, and III)

Class	4" Sieve % Passing	No. 60 Sieve % Passing	No. 200 Sieve % Passing	Clay %	Volume Change %	Max. Dry Density lb/ft3
I-A	100	15-85	0-35	0-16	0-10	100+
I-B	100	15-85	16-45	16-30	0-12	100+
II-A	100		0-45	0-16	0-10	95+
II-B	100		0-55		0-15	100+
III-A			0-75		0-25	90+
III-B					0-50	80+
III-C					0+	80-

Chert clay soils in District 6 having less than 55% passing the No. 10 sieve may be considered suitable for subgrade material.

FILL IN THE BLANKS.

2-10 The gradation analysis divides soils into four groups, which are:

1. _____
2. _____
3. _____
_____

2-11 _____ particles tend to stick together.

2-12 _____ has a low to medium plasticity.

2-13 _____ is a coarse grained soil.

2-14 Any soil that contains gravel is referred to as _____.

2-15 List the correct characteristics from the list below for each soil type given afterwards.

drains well
tends to shift
easily penetrated by water
requires confining with a plastic material
tends to flow
stable
highly plastic
highly erodible
swells when wet
strong when dry
optimum moisture is critical
high liquid limit

SAND

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

SILT

7. _____
8. _____
9. _____
10._____

CLAY

11. _____

12. _____

13. _____

GRAVEL

15. _____

16. _____

17. _____

The following shows some examples of soil types and name groups:

SANDS (50% or over of the particles are sand)

Sand

Sandy loam

Sandy clay

SILTS (50% or over of the particles are silt)

Silt

Silty loam

Silty clay loam

Silty clay

CLAYS (50% or over of the particles are clay)

Medium silty clay

Heavy clay

LOAM (over 80% sand and silt)

2-21. dry

2-22. wet

2-23. dark

Study the above lists and then answer the questions that follow.

TRUE OR FALSE

2-16 True False Silty clay contains 50% or more clay.

2-17 True False Heavy clay contains 50% or more clay.

2-18 True False Sandy loam contains 50% or more sand.

2-19 True False Loam contains less than 50% sand and silt

2-20 True False Silty loam contains 50% clay.

The soil survey sheets and lab reports also describe soils in terms of consistency and color.

Consistency describes soil in terms of its cohesion (ability to stick together) and in-place moisture content.

For dry materials, the following terms often occur:

Loose

Crumbly

Hard

Very hard

2-14. gravelly soil

2-15.
Sand
1. drains well
2. easily penetrated by water
3. tends to shift
4. stable
5. requires confining with plastic material
6. erodible

Silt
7. erodible
8. optimum moisture content
9. tends to flow
10. requires confining with a plastic material

2-26. sand

2-27. A-8

2-28. A-7

2-29. A-7

For wet soils, the following terms will be seen:

Very Soft

Soft

Firm

Stiff

Very Stiff

Hard

Color is the most obvious of characteristics. It provides some indication of what materials are in the soil.

For example:

Light or white = lime or sand

Brown = iron

Yellow = poorly drained, with iron

Gray = poorly drained

Dark = organic matter

Red = iron oxide

CIRCLE THE CORRECT ANSWER.

2-21 Crumbly soils are (dry / wet).

2-22 Stiff soils are (dry /wet).

2-23 Soils containing organic matter are usually (dark /white).

2-24 Soils containing iron oxide may be (red /gray).

2-25 Soils containing lime are usually (white /yellow).

Another method by which soils will be classified is A-Groups. Soils are arranged into eight major groups, A-1 through A-8.

A-1, A-2, and A-3 are granular soils (sand, gravel).

A-4, A-5, and A-6 are soils containing both clay and silt, and sometimes sand.

A-7 is usually a clay soil, although some silts may fall into this classification.

A-8 is the classification for soils that contain 15% or more organic matter. Muck falls into this classification.

Sand soils are classified by smaller numbers; clay soils by the large numbers.

A-8 soils cannot be used in embankments.

Soils in the following categories are called select material.

A-1
A-2-4
A-3
A-4

2-16. false

2-17. true

2-18. true

2-19. false

2-20. false

2-30. Project Engineer files and District Engineer's files

2-31. special problems

2-32. A-4, A-6 and A-7

2-33. borrow

2-34. Department's Environmental section and the Project Engineer

2-35. soil survey sheets and lab reports (a & d)

Embankments may be constructed of class A-1 through A-7 materials. However, high volume change sandy silts and plastic clays should be placed low in the fills. Consideration should also be given to wasting highly plastic clays. When A-1 or A-3 material is used in the embankment, a plastic material of the A-4, A-6, or A-7 classes should be used on the slopes.

CIRCLE THE CORRECT ANSWER.

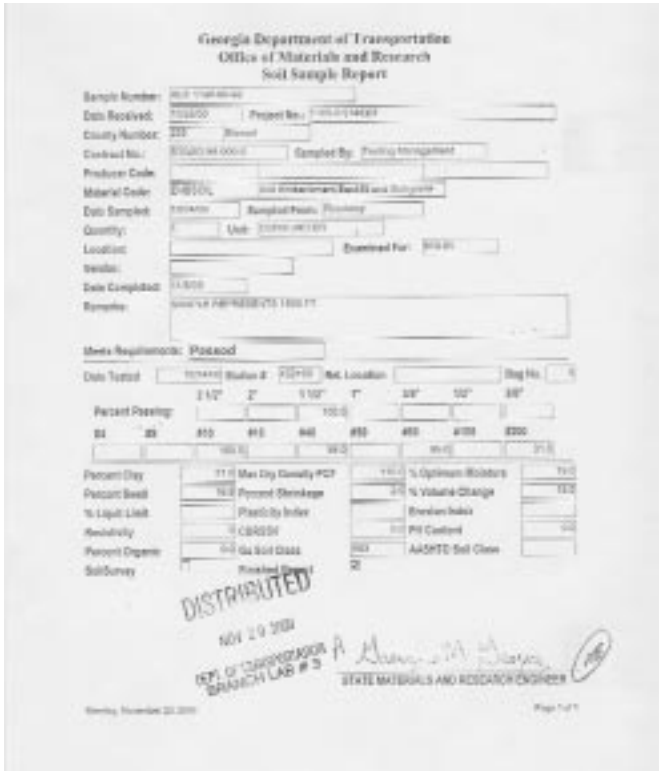
2-26 A soil classified as A-1 consists mainly of (sand / silt / clay / loam)

2-27 Muck is classified as (A-1 / A-2-4 / A-8 / A-5)

2-28 Which classification is not a select material? (A-1 / A-2-4 / A-7 / A-3)

2-29 Which material can be used to wrap embankments built of A-1 or A-3 soils? (A-2 / A-7 / A-8 / A-5)

Soils Analysis Form



Georgia Department of Transportation
Office of Materials and Research
Soil Sample Report

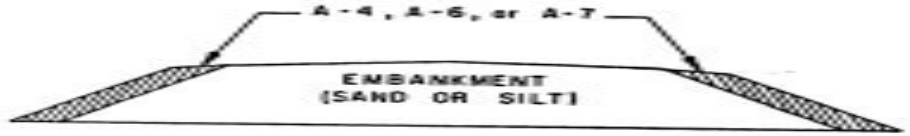
DISTRIBUTED

The contract and plans specify which materials can be used in an embankment. Generally, all A-Groups can be used except A-8; however, the Project Engineer can reject any soils (A-5, A-6, A-7-5, A-7-6) he considers unsatisfactory for the intended use. Comments about special problems with the soils should go in the remarks section of the Soils Analysis form.

Some projects require that Select Material be used in the top of the embankment. A cross-section of such an embankment would look like this.

When materials, such as sands or silt that tend to flow or shift, are used in embankments, they are wrapped with soils having much higher clay content. (A-4, A-6, A-7) to hold the embankment in place.

A cross-section of such an embankment would look like the diagram below.



2-24. red

2-25. white

2-41. A-2-4

2-42. A-3

2-43. Top of embankment

ANSWER THE FOLLOWING QUESTIONS.

2-30 Where might you find the laboratory's test results? _____

2-31 What type of comments may be found in the Remarks section of the Soils Analysis Form?

_____

2-32 Which A-Group soils might be used to confine a sand embankment? _____

REVIEW QUESTIONS

Check the correct answer (s)

2-33 Embankment materials from outside the construction area are known as:

a. right-of-way

b. special borrow

c. borrow

d. pits

2-34 If evidence of archeological artifacts is found, notify the:

a. Chief Construction Engineer

b. Department's Environmental Section

c. District Administrator

d. Project Engineer

2-35 Where will an inspector find pertinent information about soils in the construction area?

a. Soil Survey Sheets

b. Standard Specifications

c. EDSM'S

d. Laboratory Reports

2-36 Which of the following is not an Atterberg Limit?

a. Plasticity Index

b. Plastic Limit

c. Color

d. Liquid Limit

2-37 A soil for which the P.L. and L.L. are equal is:

a. Clay

b. Granular

c. Non-plastic

d. Gravelly

2-38 Which soil type is muck?

a. A-2

b. A-6

c. A-8

d. A-5

2-39 Which materials are highly plastic?

a. A-2

b. A-6

c. A-3

d. A-7

2-40 Which soil type cannot be used in embankments?

a. A-7

b. A-8

c. A-2-4

d. A-5

2-41 Which soil type is a select material?

a. A-7

b. A-8

c. A-2-4

d. A-5

2-42 What type of soil could not be used to confine a sand embankment?

a. A-7

b. A-6

c. A-4

d. A-3

2-43 Where are select materials usually used?

a. As part of the foundation

b. Top of the embankment

c. Beneath the embankment

d. Incorporated in the base course

3-4. benchmark

3-5. permanent

3-6. 2,500 feet

3-7. re-establish elevations

CHAPTER III

Layout and Grade Control/Alignment

The actual surveying of the roadway will usually be performed in advance by a survey crew. They will stake the roadway and establish elevations along the centerline and/or right-of-way.

These roadway elevations are established by a network of benchmarks through the use of a known elevation above sea level given on a National Geodetic Survey marker.

National Geodetic Survey markers are concrete pedestals with a brass information plate on the top. These monuments provide a network of known elevations throughout the state and should not be moved or destroyed without proper authorization. Such markers must be protected from damage during construction.

Should any such horizontal or vertical control monument be found in the project area, the Project Engineer, the District Construction Engineer, and/or District Location Engineer should be notified before proceeding.

FILL IN THE BLANKS.

3-1 A survey crew will usually stake the roadway and establish elevations along the _____.

3-2 National Geodetic Survey markers provide a network of known _____.

3-3 If a monument for horizontal or vertical control is found in the area of construction, the Project Engineer and the _____ should be notified.

2-36. color (c)

2-37. mon. plastic (c)

2-38. A-8 (c)

2-39. A-6 and A-7 (b&d)

2-40. A-8 (b)

A benchmark is a point of known or assumed elevation used as a reference in determining and recording other elevations in topographical surveys. Benchmarks will be placed in locations that will be permanent.

Some examples of benchmarks that might be found on a project are:

Spike in 12-inch Cedar tree – 100 ft Rt. of Centerline Station 9+79
60d nail in 16-inch Oak tree – 60 ft Lt. of Centerline Station 42+39
Angle iron along intersecting fences – 60 ft Rt. Of Centerline Station 74+45

Benchmarks should be located at the beginning of the project and every 2,500 feet thereafter. A list of benchmarks and their elevations for a project will be found in project files. Should it be necessary to re-establish elevations on the roadway, it can be done by referring to the established line of benchmarks.

FILL IN THE BLANKS

3-4 A _____ is a point of known or assumed elevation.

3-5 All benchmark locations must be _____.

3-6 Benchmarks can be found at the beginning of a project and every _____ thereafter.

3-7 Benchmarks can be used to _____ along the roadway.

3-13. Hubs

3-14. Hubs

3-15. Blue Tops

3-16. Hubs

3-17. guard stakes

The contractor typically marks the centerline using either nails or stakes. However, offset and slope stakes will be referred to for most layout and grade control. Therefore, it is necessary to reference the control points of the centerline. These points are usually the Point of Intersection (P.I.), Point of Curvature (P.C.), Point of Tangent (P.T.), and Point on Tangent (P.O.T.).

TRUE OR FALSE

3-8 True or False The centerline is the basic point of reference for the entire project.

3-9 True or False The centerline is established from reference points.

3-10 True or False Reference points are always parallel to the centerline.

3-11 True or False Reference should be perpendicular to the centerline.

3-12 True or False The reference points most often used for alignment control are the P.C., P.T., P.O.T., and P.I.

STAKES

It is the responsibility of the contractor's crew to preserve all stakes and marks. If the contractor during construction operations destroys any construction stakes or marks, replacement of the stakes will be the contractor's responsibility.

The stakes used to mark reference points on lines are referred to by various names, such as hubs, blue tops, guard stakes, tall stakes or offset stakes. These names refer to the use of the stake at a given location.

The hub is the stake from which all measurements are taken. It is usually set flush with the ground, and references a specific elevation or alignment point.

Hubs may be painted or marked by flags to make them easily visible.

3-1. centerline

3-2. elevations

3-3. location and survey engineering

3-20. The distance from the centerline to the offset hub

3-21. F=fill
7=offset distance
3:1=slope

3-22. station number

Blue tops are used for checking final grade. They are set to grade (driven into the ground until the top is at the proper final elevation) at the shoulder line.

Blue tops are usually painted or flagged in order to make them easy to see. Traditionally, blue tops were painted blue on top, hence the name, but any bright, easily visible color may be used.

Guard stakes (also called tall stakes) are placed next to a hub to mark the hub's location and to protect it from damage during construction. Guard stakes usually extend 12 inches or more above the ground. The information necessary to use the hub is often written on the guard stake.

Offset stakes are stakes set a known distance from a hub. It is common to see them on reconstruction/widening projects (stage construction often has one or more sections completed before parallel or adjacent construction begins). In other words, hubs will be lost when the road is constructed but references may be needed to build other portions of the roadway.

CIRCLE THE CORRECT ANSWER.

3-13 (Guard stakes/hubs) are set nearly flush with the ground.

3-14 (Hubs/Blue tops) are used to reference elevation and alignment points.

3-15 (Guard stakes/blue tops) are used for checking final grade.

3-16 (Hubs/blue tops) may be used on any reference line.

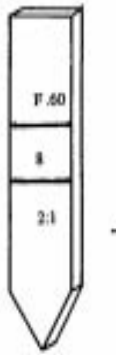
3-17 The information necessary to use the hub is usually written on the (blue top/guard stake).

The information needed to use the hub includes the following:

Station Number
Offset Distance
Cut and/or Fill
Slope

This information will be available for each hub. It will generally be written on the guard stake and in a field book. In some instances it may also be provided by a computer print out. In any case, both the contractor and the inspector must have access to it.

If the information is marked on the guard stake, the amount of cut or fill, offset distance, and slope will be written on the front. Procedure for marking stakes varies from District to District. Most information is on the front of the stake as shown in the picture that follows. Station number is on the back of the stake.



The offset distance is the distance from the centerline to the offset hub. It may be circled to indicate that it means offset.

ANSWER THE FOLLOWING QUESTIONS.

3-18 What information is needed to use the offset hubs? _____

3-19 Where can this information be found? _____

3-8. true

3-9. true

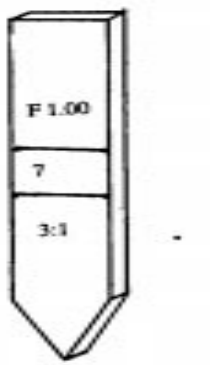
3-10. false

3-11. true

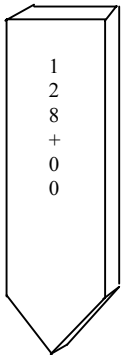
3-12. true

3-20 What is offset distance? _____

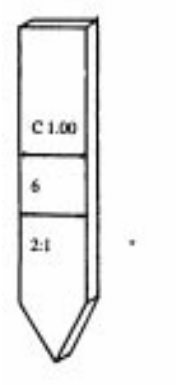
3-21 Label the information shown on the front of this guard stake.



3-22 Label the information shown on the back of this guard stake.



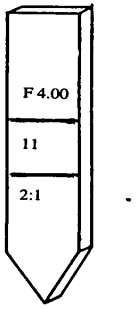
Information about cut (C) and fill (F) will be marked on the front of the guard stake. The figures for cut or fill refer to the difference in elevation from the hub to the required elevation on the roadway (normally the outside shoulder point). The cut information written on the stake will indicate that the required elevation at a given distance from the hub is below that of the hub. The distance is written below the cut.



For example: The stake shown above indicates a cut of 1 foot at a distance of 6 feet from the hub marked by this guard stake.

The fill information will indicate that the required elevation at a given distance from the hub is above that of the hub.

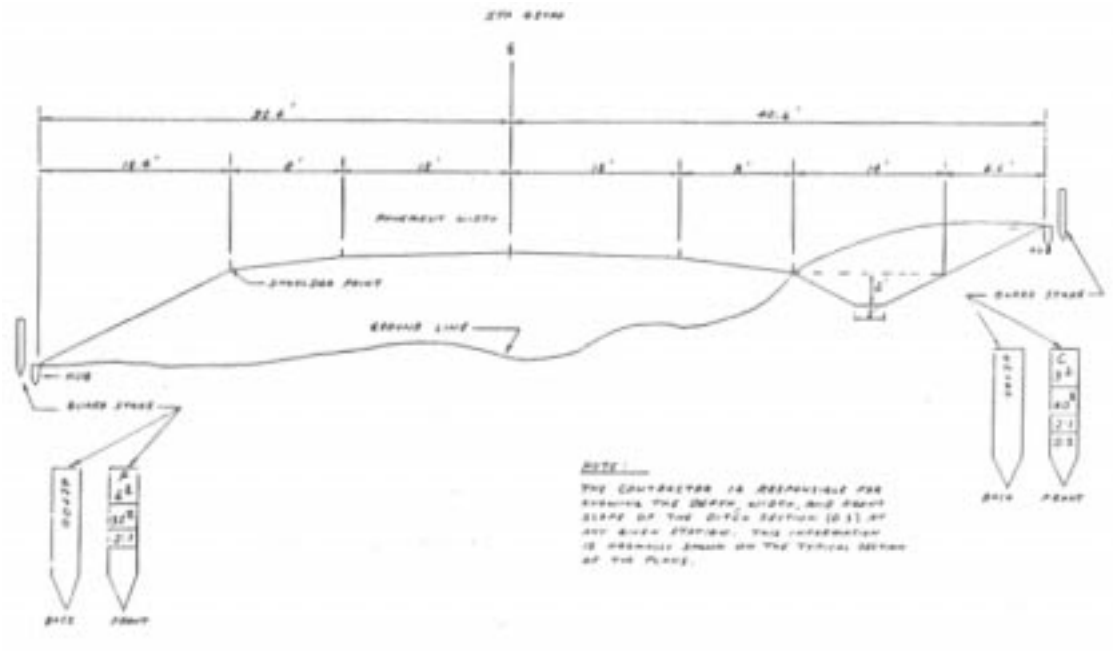
For example: The stake shown below indicates a fill of 4 feet at a distance 11 feet from the hub marked by this centerline to the guard stake.



3-18. station number
offset distance
cut or fill
slope

3-19.
a. on the guard stake
b. in a field book
c. computer print out

This cross section depicts how such stakes would be used as points of reference on a project.



To the left of the centerline, at distance of 27 feet from the centerline, a fill of 2 feet above hub elevation is required. To the right of the centerline, a cut of 1 foot is required 37 feet from the centerline.

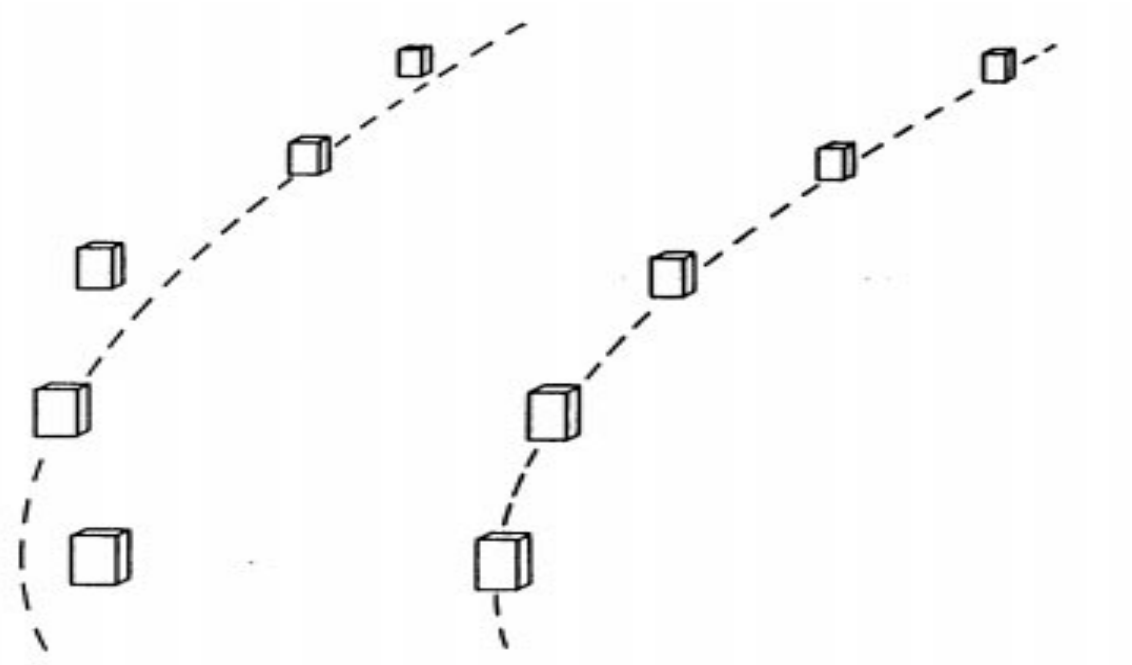
SLOPE STAKES

Slope stakes mark the top of the backslope and the bottom of the frontslope.

The limits of cuts and fills can be marked by hubs, guard type stakes, or flags. However, all slopes and elevations should be checked from a hub.

Again the information necessary to use the hubs will be written on guard stakes or otherwise provided.

Because slope stakes locate the outer limits of cuts and fills, their layout can be used to check the accuracy of these limits.



The stakes should form a smooth line like the view at the right above. Should a slope stake be out of line, its position should be corrected, so that the finished edge will be smooth.

FILL IN THE BLANKS.

3-23 Slope stakes mark the _____ of the backslope and the _____ of the frontslope.

3-24 _____ locate the outer limits of cuts and fills.

3-25 The alignment of the slope stakes should be checked, to ensure that the _____ is smooth.

Checking Grade and Slope

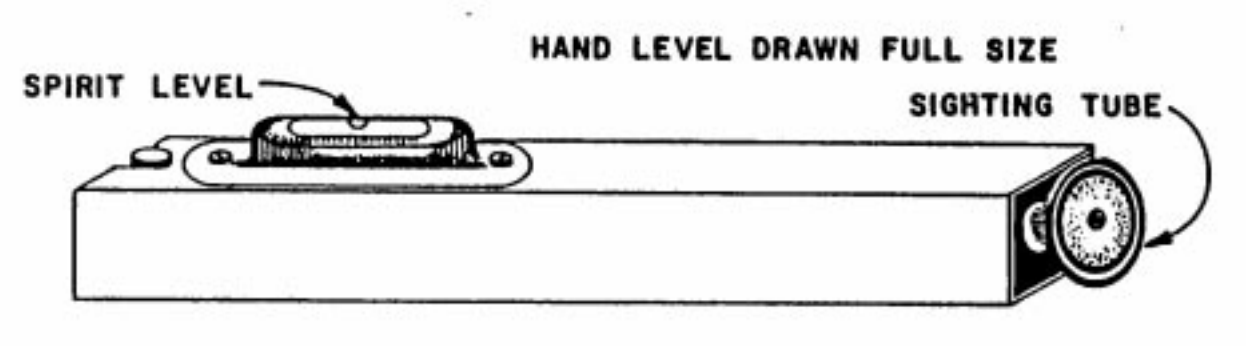
The contractor performs the grading work according to the plans and specifications. The inspector must be certain that the contractor's grades (elevations) and slopes agree with the plans. It is important to remember that layout is the responsibility of the contractor, not DOT personnel.

Grade is expressed as a certain elevation above sea level. When the embankment construction approaches grade or if problems occur, the Inspector should check that the construction agrees approximately with the information on the stakes. This is referred to as checking rough grade.

To check rough grade a metallic tape, a hand level, and a level rod are needed.

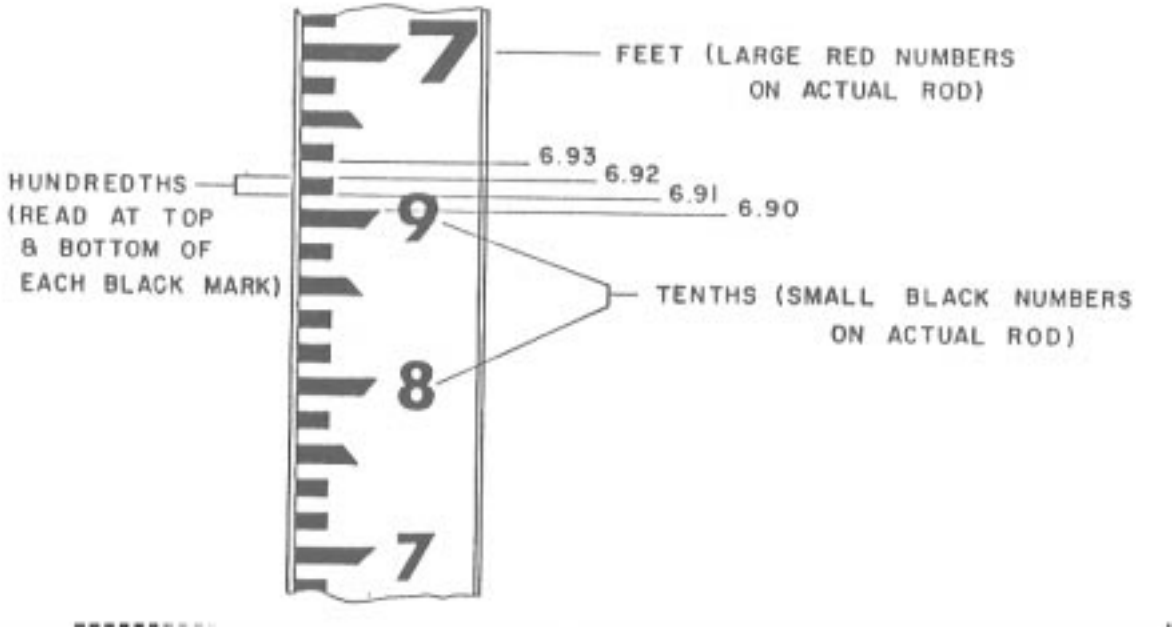
A metallic tape is cloth tape containing metal strands. It is either 50 or 100 feet long, and marked in feet, inches, and tenths.

A hand level can be used only when measurements do not need to be precise. It should not be used for distances greater than about 15 feet or when an accuracy is greater than 0.1 foot (one-tenth of a foot) is expected.



The spirit level is reflected by a slanted mirror, so that the bubble is visible when you look into the tube. When the bubble is centered, the level is being held in its proper position.

A typical level rod is a graduated wooden or fiberglass rod that comes in two or more pieces that slide into each other. It is marked in feet, tenths of a foot, and hundredths of a foot and can be read to the thousandth of a foot.



The large number represents feet. The small numbers represent tenths. The hundredths are read at the bottom and top of each black mark. The thousandths are read halfway between each hundredth mark. (0.005)

TRUE OR FALSE?

3-26 True False Grade is a certain elevation above sea level.

3-27 True False Rough grade is checked when embankment construction is close to grade.

3-28 True False A metallic tape is made of steel and is marked in feet, inches, and tenths.

3-29 True False When using a hand level, the bubble tells you if the level is being held in its proper position.

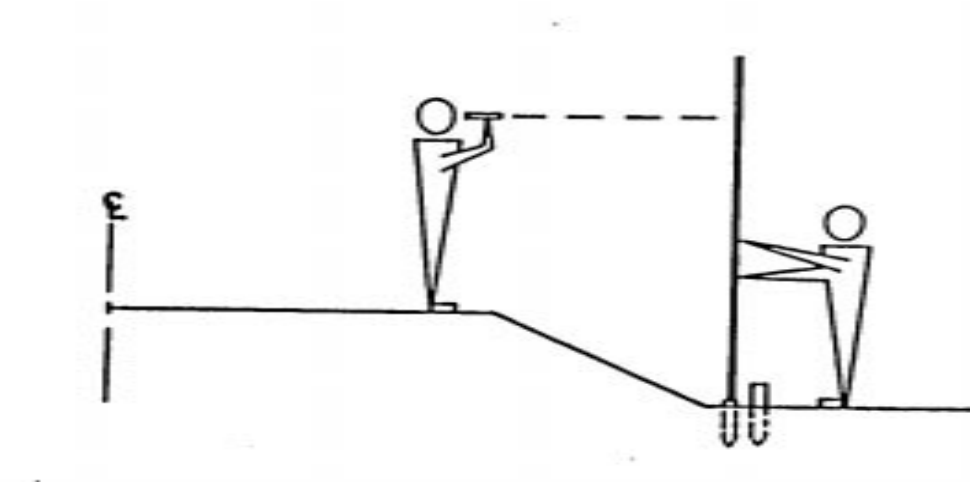
3-30 True False A level rod is marked in feet, tenths of a foot, hundredths of a foot, and can be read to ten thousandths of a foot.

3-23. top and bottom

3-24. slope stakes

3-25. line

In order to check rough grade, the inspector should review the contractors survey books and should also check elevations on at least one station, i.e. edge of pavement elevation, centerline elevation, and ditch elevations. It is not expected that an inspector review each and every station throughout a project. However, random checks are encouraged. Check with your Area Engineer for guidance.



3-34. Yes

The illustration above depicts what would be visible through the level. Take the reading from the rod where the dark line crosses the level.

Let it be noted that the inspector must exercise care in holding the level. Variations in stance or level position can substantially alter readings.

ANSWER THE FOLLOWING QUESTIONS BASED ON THE INFORMATION GIVEN.

Eye level is 1.710 at the hub. It is 2.500 at the ditch bottom. Stake indicates 0.900 ft of cut at ditch bottom.

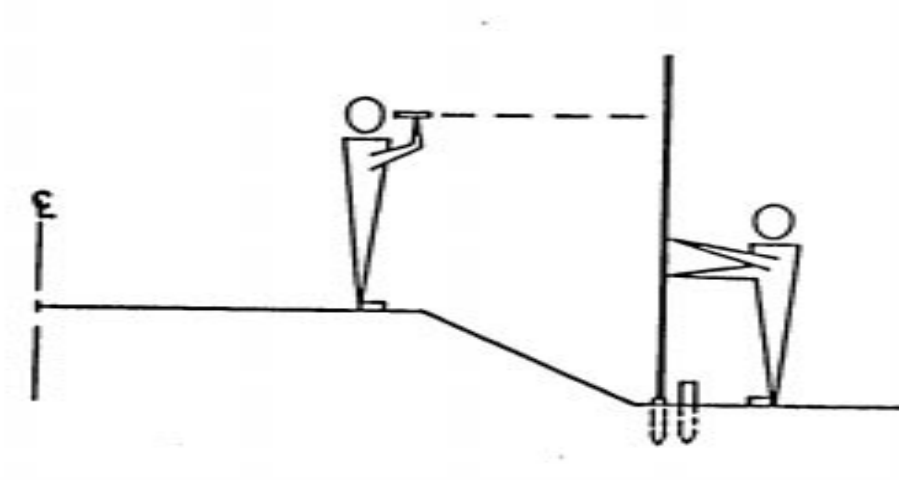
3-31 Does the cut meet the requirements on the stake? _____

3-32 What does the cut measure? _____

3-33 What should it measure? _____

The process of measuring a fill grade is similar to the one just discussed for cuts.

The rod is placed on the hub at the toe of the slope. Then the rod is sighted with a hand level.



3-26. true

3-27. true

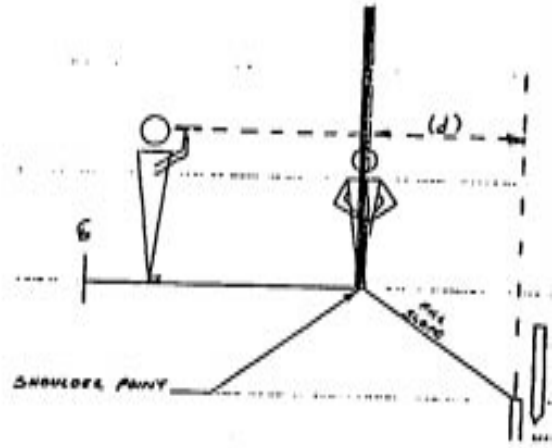
3-28. false

3-29. true

3-30. true

Then, from the information on the slope stake, the rod man measures the correct distance from the hub and places the rod on the ground at that point.

See the following illustration.



3-35. 4:1

NOTE: d = fill weight + slope

For example: f = 2.500 @ 2:1 slope; therefore, d = 2.500 X 2 = 5.000

If the slope stake indicates a fill of 1.200, the Inspector would take a reading on the hub, the rod man would measure over the specified distance to the shoulder point and place the rod at this point on the embankment. If the rod sights 2.600 at the hub and 1.400 on the fill, then the grade is correct. The fill is 1.200 ft above the elevation of the hub.

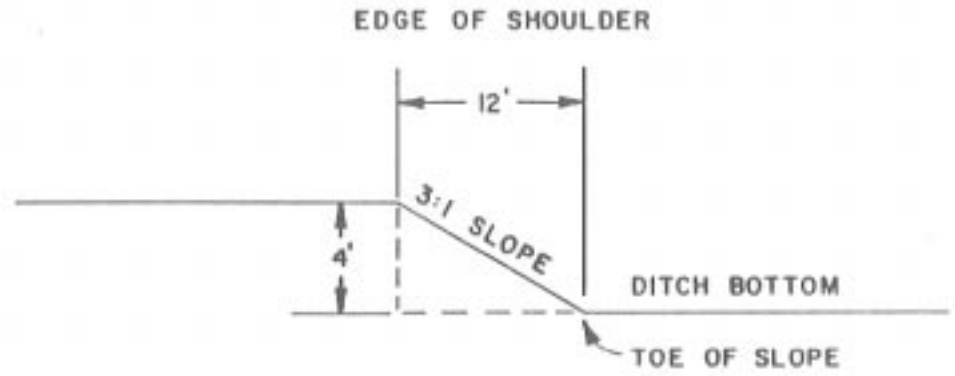
ANSWER THE FOLLOWING QUESTION BASED ON THE INFORMATION GIVEN.

The slope stake reads F 0.600. Eye level at the hub is 2.500 ft. Eye level on the fill is 1.900 ft.

3-34 Does the amount of fill agree with the requirements on the stake? _____

Besides being useful in checking grade, slope stakes are needed to check slope.

Slope is expressed in terms of the number of feet of vertical drop of an incline compared to the horizontal distance covered by the drop. Slope is then written as a numerical ratio.



For example, if the top of the embankment is 1 foot higher than the ditch bottom, and the toe slope is 3 feet from the shoulder edge (horizontal distance), the slope would be expressed as a 3:1 slope.

To figure slope, the Inspector must first check grade.

After grade is established, the metallic tape is used to measure the horizontal distance between the edge of the shoulder and the toe of the slope.

3-31. no

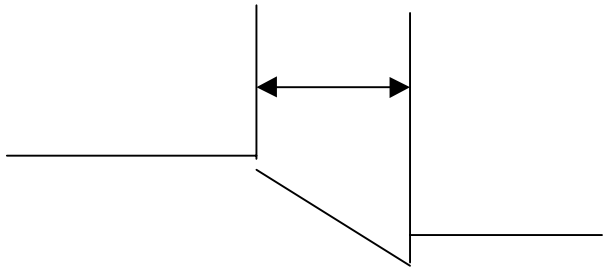
3-32. 0.790 feet

3-33. 0.900 feet

3-39. 2

3-40. 2:1

3-41. yes



If the horizontal distance measures 3 feet, and grade has been established as 1 foot above the hub, to determine slope, the amount of fill (1 foot) is divided into the horizontal distance (3 feet). The answer is the rate of slope (3) to each foot of vertical drop, 3:1.

The required rate of slope will be given in the plans. It may also be recorded in the field book or on the computer print out.

3-35 Work the following problem based on the information given.

Eye level at the toe of the slope is 3 ft.

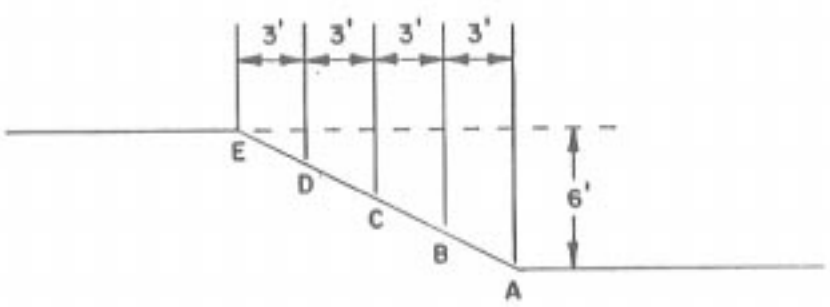
Eye level at the edge of shoulder is 2 ft.

The horizontal distance from the toe of the slope to the edge of the shoulder is 4 ft.

What is the slope? _____.

When checking a very long or steep slope such as at a bridge, in order to be certain that the slope is uniform, several points along the slope should be checked.

For example:



To check this slope, first find eye level at A and at B, then subtract to determine grade.

Eye level at A is 4 ft and at B is 3 ft, the amount of fill between A and B is 1 ft. The horizontal distance is 2 ft. Eye level at B is 3 ft and at C is 2 ft. The amount of fill between B and C is 1 ft. The horizontal distance is 2 ft. The horizontal distance is 2 ft between each set of points.

COMPLETE THE CALCULATIONS FOR THIS SLOPE.

3-36 If eye level at C is 2 ft and at D is 1 ft, the amount of fill between C and D is _____.

3-37 If eye level at D is 1 ft and at E it is 0 ft the amount of fill between D and E is _____.

3-38 Add the amounts of fill between each point. _____

3-39 Divide the fill into the horizontal distance. _____

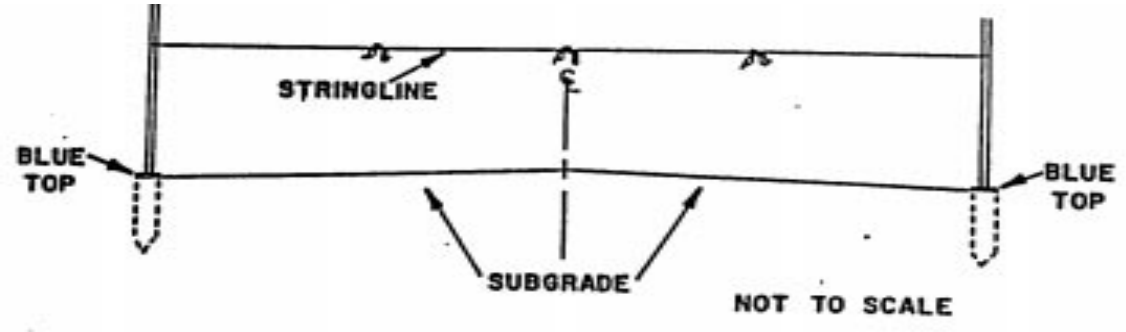
3-40 What is the slope? _____

3-41 Is the slope uniform? _____

Finished Grade

When the contractor has the embankment completed, the inspector must check the finished grade and write these grades in a field book by station number, carefully ensuring that the Departments specification tolerance is met. This helps control quantity underruns and overruns. To check the finished grade, the subgrade surface is measured to be sure that it is in accordance with the plan typical section. This cannot be done until after the blue tops are in place at the edge of the embankment.

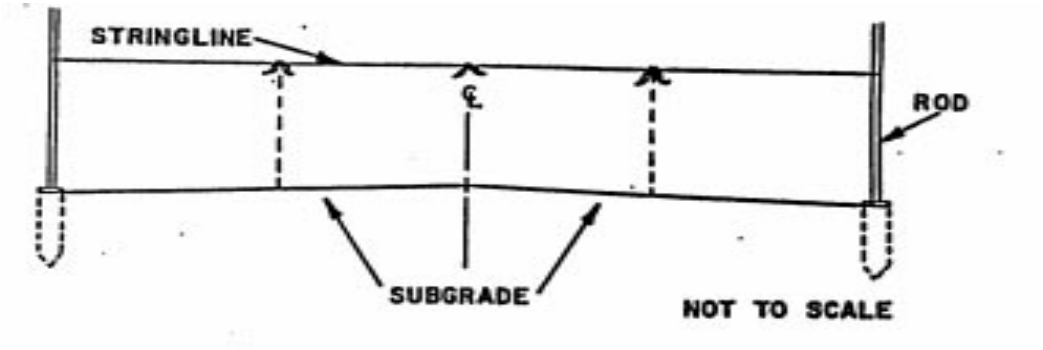
Finished grade is checked with a stringline tied to stakes or metal rods placed on top the blue tops on each side of the roadway. Then measurements are taken from the surface to the string.



Suppose the plans indicate the subgrade surface should decrease from the centerline 0.02 per foot.

To check finished grade, place the rods on the blue tops and pull the string tight. Then decide where to take measurements (at the centerline and 10 feet on either side of it). Put a “flag” on the stringline at these points.

Next, measure from the flags to the surface.



If at the centerline the distance from string to roadway measures .302 ft, at 10 feet from each side, it should measure .322 ft. This is 0.02 ft for each foot or .20 for 10 feet.

WORK THE FOLLOWING PROBLEM.

3-42 The plans indicate that the surface should decrease 0.03 ft per foot. If the centerline measures .335 ft from the string line, what should the measurement be 3.00 ft on either side? _____

Staking for Structures

Besides staking the general alignment of the roadway, the contractor is also responsible for establishing and staking the locations and grades for all structures, such as cross drains, box culverts, bridges, etc. The contractor is also required by the Specifications to submit layout sketches to the project manager.

Staking for a simple structure, such as a culvert cross drain or a side drain, requires only grade stakes indicating the elevations of the flow line at each end of the structure and line stakes set along the axis of the structure.

3-36. 1 foot

3-37. 1 foot

3-38. 2 feet

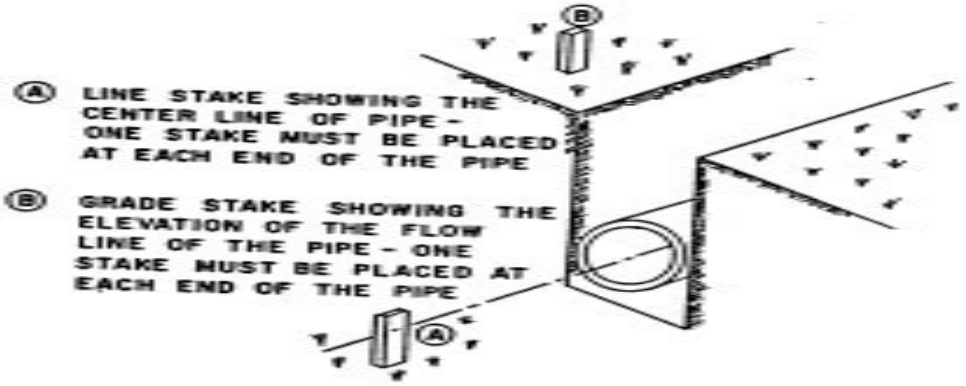
3-51. the line of project benchmarks

3-52. (d) the centerline

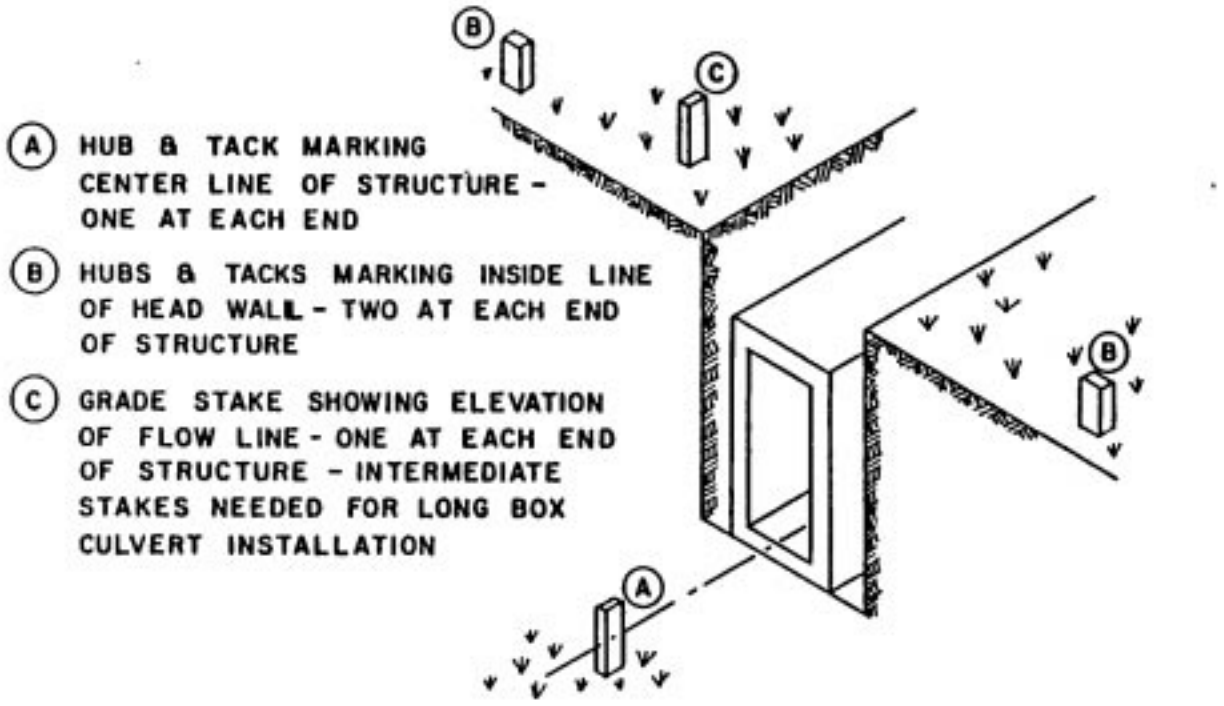
3-53. (a) the centerline

3-54. (c) contractor

3-55. (a) hub



For larger box culverts, more detailed staking will be required. These stakes must include a hub and tack point upstream and downstream from the end of the structure (A), as well as hubs marking the inside line of each headwall (B) and the cut to flow line (C).



More complex structures, such as bridges, require extremely detailed staking and alignment procedures.

TRUE OR FALSE?

3-43 True False The locations and grades for all structures must be stakes.

3-44 True False Cross drains require grade stakes for flow line at only the outfall end of the culvert.

3-45 True False Line stakes must be placed along the axis of a side drain.

3-46 True False Bluetopping is always required for cross drains.

3-47 True False For larger box culverts, hubs are used to mark the inside line of each headwall.

3-48 True False A hub and tack point must be placed both above and below both ends of a box culvert.

REVIEW QUESTIONS

Check the correct answer(s).

3-49 National Geodetic Survey markers provide

a. The A-Group classification of the soil in the area

b. A known elevation above sea level

c. Grades for cut and fill

d. The location of the nearest project benchmark

3-50 If a horizontal or vertical control monument is found in the construction zone, it should be reported to

a. National Geodetic Survey Headquarters

b. The project engineer

c. Project manager and District Construction Engineer

d. The Location Engineer

3-42. 0.245

3-61. slope stakes

3-62. slope stakes

3-63. transit

3-64. level

3-65. at the top of the black 100ths line

3-51 To re-establish elevations along the roadway, refer to

a. The line of project benchmarks

b. A National Geodetic Survey marker

c. The preceding hub

d. The contractor's records

3-52 The basic point of reference for the entire project is

a. A national Geodetic Survey marker

b. The benchmark line

c. The offset line

d. The centerline

3-53 The control points such as the P.C., P.T., and P.O.T are always referenced to the

a. Centerline

b. Right-of-way limits

c. Line of levels

d. Shoulder line

3-54 The responsibility for protecting all stakes and marks on a project rests with the

a. Project Engineer

b. Excavation and embankment Inspector

c. Contractor

d. Survey party

3-55 The stake from which all measurements are taken is the

a. Hub

b. Blue top

c. Guard stake

d. Tall stake

3-56 The stakes used for checking final grade are called

a. Hubs

b. Blue tops

c. Guard stakes

d. Tall stakes

3-57 Blue tops are placed at the

a. Ditch bottom

b. Right-of-way line

c. Shoulder line

d. Centerline

3-58 The stakes, which may have valuable information, marked on them are

a. Blue tops

b. Hubs

c. Guard stakes

d. Flags

3-59 Where would grade and slope information not be found?

a. Computer print out

b. Field book

c. Standard Specifications

d. Guard stake

3-60 Base line refers to the

a. Offset line

b. Line of levels

c. Centerline

d. Slope stake line

3-43. true

3-44. false

3-45. true

3-46. false

3-47. true

3-48. false

3-49. (b) a known elevation above sea level

3-50.
(b) project engineer
(d) location and Design Engineer

3-61 The top of the backslope and the bottom of the frontslope are marked by

a. Grade stakes

b. Guard stakes

c. Slope stakes

d. Bench marks

3-62 To check the outer limits of cuts and fills, check the alignment of the

a. Right-of-way stakes

b. Slope stakes

c. Bench marks

d. Blue tops

3-63 Which is not needed to check rough grade?

a. Metallic tape

b. Transit

c. Hand level

d. Leveling rod

3-64 When the bubble is centered on the line in a hand level, the level is

a. Too high

b. Level

c. Too low

d. just right

3-65 On a level rod, 2.100 would be read

a. In the white space

b. At the top of the black hundredths line

c. At the bottom of the black hundredths line

d. At the bottom of the hub

4-1. true

4-2. false

4-3. true

3-66 To check finished grade, _____ are used.

a. Blue tops

b. Guard stakes

c. Bench marks

d. Slope stakes

3-67 The plans indicate that the subgrade surface decreases 0.015 ft per foot. Centerline measurement to the stringline is 1 foot. At 3 feet on either side of the centerline, the measurement should be

a. 3 feet

b. 3.015 feet

c. 4 feet

d. 1.045 feet

3-68 The elevation of the flow line of a cross structure must be staked

a. At each end of the structure

b. Along the axis of the culvert

c. At the right of way

d. Only at the outfall

3-69 For large box culverts, hubs alone mark

a. The inside line of the headwall

b. The outfall end

c. The limits of backfill

d. The cut to flow line

3-70 Eye level at a hub is 1 ft. Eye level at ditch bottom is 2 ft. What is the depth of the cut?

a. 1 ft

b. 2 ft

c. 3 ft

d. .5 ft

3-56. blue tops

3-57. shoulder line

3-58. guard stakes

3-59. standard specifications

3-60. offset line

CHAPTER IV

Sequence of Operations/Equipment

All equipment should be performing properly. If the equipment is not providing satisfactory results, it should be repaired or replaced. The inspector should advise the contractor if he sees visible fluid leaks or is concerned about the safety of a piece of equipment.

Machinery used for earthwork procedures falls into two general categories of use - excavation and compaction.

4-7. clearing

Land based excavation equipment includes scrapers and crawler tractors bulldozers, draglines, backhoes, trenchers, and motor graders.

4-8. grubbing

Material for hydraulic embankments is excavated by suction dredge.

4-9. Right of Way

Before embankments can be compacted, the soil must be at the proper moisture level. If the material is too dry, water trucks are necessary to dampen it; if it is too wet, a disk must be used to break up the soil to allow it to dry.

4-10. burning

If water trucks are utilized, the spray bar at the back must operate properly. It should distribute water evenly over the surface.

4-11. Standard Specifications

TRUE OR FALSE?

4-1 True or False Any equipment that does not produce satisfactory results cannot be used on the project.

4-2 True or False Land based excavation equipment includes suction dredges.

4-3 True or False Water trucks are needed when the soil is below the proper moisture content

Any type of compaction equipment that will achieve the required density can be used on embankments, as long as no detrimental side effects, such as differential settlement, occur. Generally pneumatic, sheepsfoot, or vibratory rollers are employed. Differential settlement is uneven settlement. It can cause damage to cross drains and underlying utilities.

Pneumatic rollers have rubber, air-filled tires. The tires should be smooth (without tread) and should all be equally inflated.

The weight of some pneumatics can be adjusted by adding sand or water or both to the ballast box. Increasing weight will increase the compactive ability of the roller. The inflation pressure of the tires also affects the compactive ability of the roller. Some pneumatics can adjust tire inflation during operation.

Sheepfoot rollers have metal drums with prong-like projections. These projections traditionally are shaped like sheep's feet, hence the name. However, other configurations can be used. These projections should all be uniform and in good condition. The weight of sheepsfoot rollers can also be adjusted by adding sand or water to the ballast box.

TRUE OR FALSE

4-4 True or False Only pneumatic or sheepsfoot rollers can be used to compact an embankment.

4-5 True or False Sand and/or water can be added to the ballast box of both the pneumatic and sheepsfoot rollers to increase roller weight.

4-6 True or False Sheepfoot rollers get their name from the shape of the projections on the drum.

Clearing and Grubbing

Clearing and grubbing operations remove trees, shrubs, sod, and other natural materials found in the construction area. Specifically, clearing refers to the removal of trees, brush, and boulders and grubbing to the removal of roots and stumps.

3-66. blue tops

3-67. 1.045 feet

3-68. at the end of the structure

3-69.
(a) the inside line of the headwall
(d) the cut to flow line

3-70. (a) 1 foot

Prior to any clearing and grubbing operations beginning, the contractors erosion control plan shall be approved and erosion control devises shall be in place.

The limits of clearing and grubbing operations are usually indicated on the plans. In general, the Standard Specifications require the entire construction area to be cleared and grubbed within the right-of-way limits.

Georgia Air Control Regulations

4-12. false

It is the responsibility of the contractor to dispose of all trees, brush, and other vegetation removed during clearing and grubbing operations. Permits may be required for the burning of cleared brush depending on the project location. It is the contractor's responsibility to obtain the necessary permits, and to comply with all state and local ordinances.

Regulations for such burning are given in the Standard Specifications Subsection 201.02.E.2. The Inspector should familiarize himself with these rules, so that he can be certain they are being obeyed.

FILL IN THE BLANKS

4-13. true

4-7 The removal of trees, brush, and boulders from the project area is known as _____.

4-14. true

4-8 The removal of roots and stumps is referred to as _____.

4-9 The entire construction area is usually cleared and grubbed (within the limits of the _____).

4-10 One method of disposing of material that has been cleared and grubbed is _____.

4-11 Rules for burning cleared material are given in Subsection 201.02.E.2. of the _____.

The following is a summary of the Standard Specifications Subsection 201.02 that is concerned with combustible material resulting from the clearing and grubbing process.

"All combustible material except sawdust piles may be burned on the right-of-way except where prohibited by local air pollution control regulations. Burning on the right-of-way shall be so done as to prevent fire from spreading to living trees and shrubs…Care shall be taken to prevent damage to all public and private installations…and to the traveling public.

When the right-of-way, or any portion thereof, lies within an area where burning is restricted by a local code, it shall be the responsibility of the contractor to abide by such a code. When necessary the contractor shall obtain, at his expense, suitable areas for burning or disposing of the combustible material….

Sawdust, when present on the right-of-way, shall be completely removed from within the construction limits. The sawdust may be hauled to approved disposal areas in accordance with the provisions…"

The area to be cleared and grubbed should be staked. It is possible that these operations will be covered under different pay items. For example, part of the construction area may be scheduled for clearing and grubbing, another section for clearing, only, and still another section may require only selective clearing. When such a situation exists, the areas falling under each pay item must be clearly marked.

Any trees that are to be left standing should be clearly flagged, usually with bright tape. During construction operations, all possible precautions must be taken to ensure that such trees are not injured.

Clearing and grubbing are hazardous operations. All project personnel should be made aware of areas in which clearing is taking place. They should continually be conscious of the location of equipment and operations to avoid injury from falling limbs or trees.

There are some specific Occupational Safety and Health Administration (OSHA) regulations that the contractor's personnel must follow during clearing and grubbing operations. Compliance with OSHA rules is the responsibility of the contractor in accordance with Specification 107.01.

4-4. false

4-5. true

4-6. true

4-12 True or False To know which trees are to be left standing, the plans must be consulted.

Areas are usually cleared by bulldozers that remove and stack trees. Operations usually proceed from the center outward in either direction. Trees should be felled in a predetermined order to prevent them from lodging against each other, creating a difficult removal problem.

To prevent damage to existing structures or pavements, trenches can be dug around the tree and the roots chopped away before the tree is removed.

When trees must be removed in urban areas, their limbs should first be removed by hand (e.g. with chain saws). It may then be necessary to cut the trees down in sections to prevent damage to surrounding buildings.

In areas where clearing operations may interfere with traffic (e.g. widening jobs), any necessary traffic control shall be in place prior to beginning any work.

Stumps are removed during grubbing operations. They are pulled out by winches, burned, or blasted. After stumps are removed, the holes should be filled to prevent the accumulation of water.

All stumps, roots, and nonperishable solid objects must be removed to a minimum of 2 feet below subgrade, unless otherwise authorized. When authorized, such objects may be allowed to extend 6 inches above the ground line or low water level. Consult the plans and/or contract for requirements of stump removal.

TRUE OR FALSE

4-13 True or False Trees that lodge against each other after being felled can be difficult to remove.

4-14 True or False Chopping the roots before attempting to remove a tree located near pavement is one method of preventing damage to the pavement.

4-15 True or False Stump holes are filled to prevent water from accumulating.

4-16 True or False Stumps can be left 2 feet above natural ground level.

EMBANKMENT CONSTRUCTION

Ground Preparations

The process of embankment construction is basically a combination of cut and fill.

Cuts are made when the required grade is below the level of the natural ground.

Fills are used when the required grade is above the level of the natural ground.

Before fill material can be placed, the embankment foundation must be properly prepared. The following excerpts from the Specifications provide guidelines for this work.

Preparation for Embankments: Embankment construction shall not be started until clearing and grubbing for the embankment area is completed as specified in Section 201.

Depressions and Undercut Areas: All depressions below the ground surface and areas undercut to remove unsuitable or unstable material shall be filled to the ground surface with suitable material and compacted in accordance with “c” below before construction of the embankment is begun.

Scarification and Other Preparation: Except in inundated areas, the entire area upon which the embankment is to be placed shall be plowed and scarified to a depth of at least 6 inches. Before the embankment is placed, all loosened solids shall be recompacted to the approximate density of the underlying soil. Where required, benches shall be cut as specified in “a” above

Compaction Under Shallow Fills: Where the depth of fill and surfacing is 3 feet or less, the original ground shall be compacted a minimum of 12 inches deep to a least 95 percent of the maximum laboratory dry density as determined from representative samples of the material being compacted (GDT 7, 24, or 67,whichever is applicable. In-place density of the compacted fill will be determined in accordance with GDT 20, 21, or 59, whichever is applicable.

Embankments over existing roads, parking areas, floors, etc.

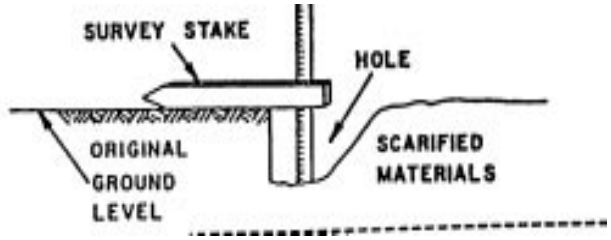
(1) Unpaved Roads and Flexible Pavements: All portions of existing unpaved, flexible pavements and the like, shall be thoroughly plowed or scarified and cleavage planes shall be destroyed before the embankment is placed.

(2) Rigid Pavements and Surfaces: If the new embankment is not to be more than 3 feet deep, all of the old pavement with rigid surfaces shall be removed. Rigid pavements remaining in ground place which are within 10 feet of finished grade shall be broken to the extent that the section exceeding 3 feet squared remains intact.

4-25. true

The project personnel must check that the ground is being scarified or broken to the required 6-inch depth. To do so, the edge of the disked material should be cleared away, so that the depth of scarification can be measured against the existing ground.

4-26. false



4-27. true

It is important to measure the depth of scarification against the original ground level, because the scarified soil will “fluff” causing the scarified area to appear deeper than it really is.

Fluff refers to the tendency of soils to increase in volume because the space between the particles increases.

Not all soils fluff the same when scarified. The amount of fluff depends on the type of soil, the moisture content, the original degree of compaction, and the method used in breaking up the soil.

FILL IN THE BLANKS.

4-17 To lower the level of the natural ground to that of grade, a _____is needed.

4-18 _____ is required when the required grade is above that of the natural ground.

4-19 When a fill will be _____ in thickness, all sod and other objectionable material must be removed.

4-20 Before fill material can be placed, the natural ground must be broken up to a depth of _____.

4-21 After the natural ground has been disked or scarified, it must be recompacted to the approximate density of _____.

4-22 To check the depth of scarification, the Inspector should measure from the bottom of the scarified area to the _____.

4-23 The tendency of soils to increase in volume when broken up because the space between the particles increases is known as _____.

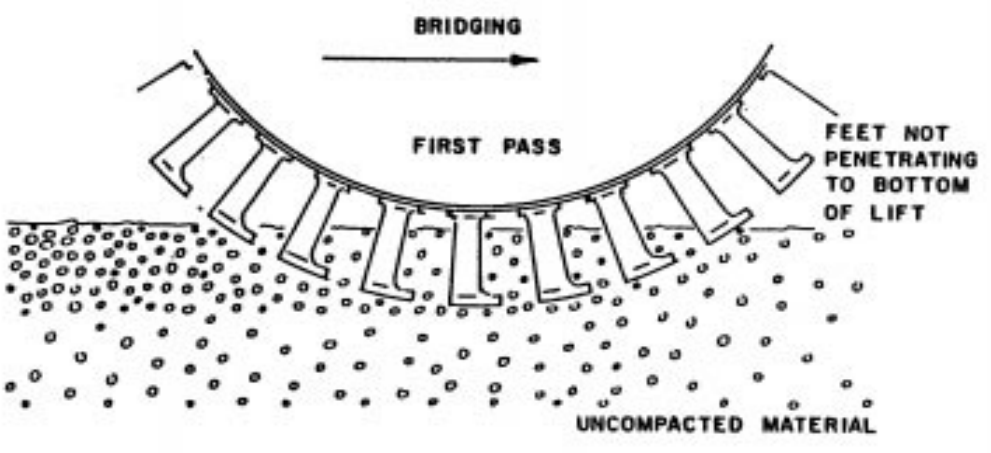
4-24 The amount of fluff depends on _____.

The contractor can recompact the scarified ground by any acceptable means. Generally he will use either a sheepsfoot or a vibratory roller.

Proper moisture is necessary for adequate compaction to take place. If a sheepfoot roller is used on material that is too wet, mud will collect between the roller feet and very little compaction will be achieved. If the material over which a sheepsfoot is used is too dry, the feet of the roller will not penetrate to the bottom of the lift. This problem is known as “bridging” and will result in improper compaction. The material at the bottom of the lift will not be compacted.

4-15. true

4-16. false



4-28. with each pass the feet of the sheepsfoot roller penetrates less and less

4-29. roller feet do not penetrate deep enough

4-30. soil too dry, roller weight insufficient

4-31. Drum will ride of material

4-32. Observe the holes left by the feet and the distance between the drum and the soil

TRUE OR FALSE

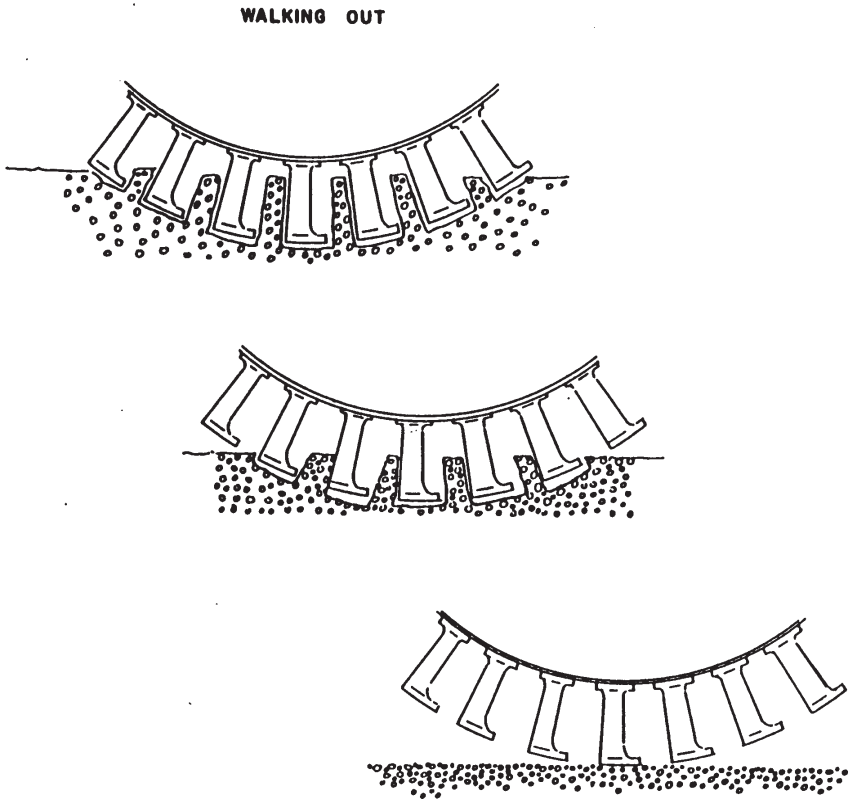
4-25 True or False Moisture content will affect compaction.

4-26 True or False If soil being compacted by a sheepsfoot roller is too wet, bringing will occur.

4-27 True or False If bringing occurs, the material at the bottom of the lift will not be compacted.

In order to compact properly, the feet of the sheepsfoot roller must penetrate to the bottom of the disked material on the first pass. Each time the roller passes over the material, it should penetrate less. This action of penetrating less and less with each pass is called “walking out.” The roller should “walk out” properly.

Refer to the following sketches.



To check the "walk-out" of a roller, observe the holes made by the feet in the soil, as well as the distance between the drum and the soil.

The sheepfoot roller will walk out too soon if the soil is too dry. The roller will also walk out too soon if the drum is not heavy enough. If the drum is the correct weight, the feet will penetrate to the bottom of the disked material, but the drum will not "ride" on the material.

4-17. cut

4-18. fill

4-19. 3 feet or less

4-20. 6 inches

4-21. the surrounding ground

4-22. original ground level

4-23. fluff

4-24. type of soil, moisture content, original degree of compaction, and the method used to break up the soil

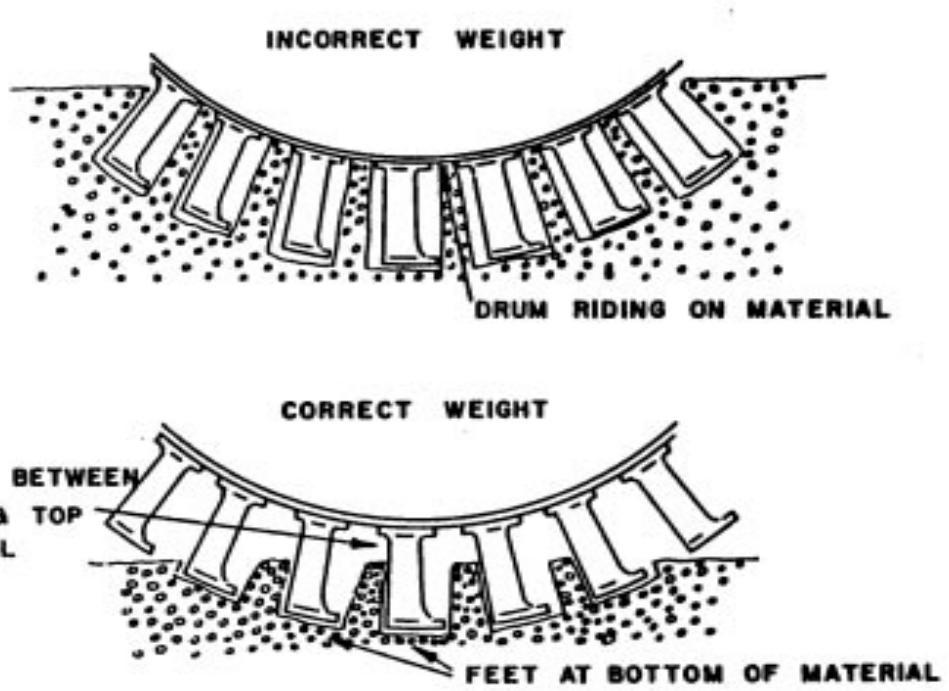
4-33. false

4-34. true

4-35. true

4-36. true

4-37. false



ANSWER THE FOLLOWING QUESTIONS.

4-28 Define the term “walk out.” _____

4-29 Define the term “bridging.” _____

4-30 What conditions will cause a sheepsfoot roller to walk out too soon?

_____

4-31 How can an inspector tell if the roller is too heavy?

_____

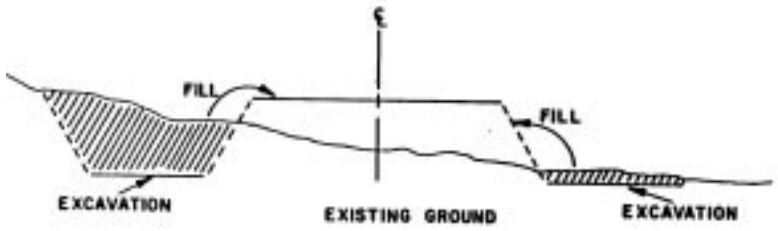
4-32 How can an inspector tell if a roller is walking out properly?

_____

FILLS

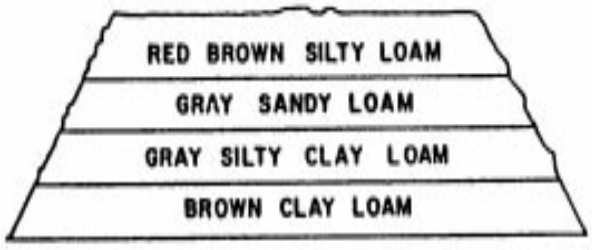
Most embankments are fills built from either unclassified excavation material or borrow.

For some embankment jobs, the contractor will excavate the side ditches and use this material (unclassified excavation) to construct the fill.



If borrow is to be used for fill material, it will be excavated at the pit, hauled to the job site in trucks or other hauling equipment, and placed on the prepared foundation.

When borrow is to be used, project personnel should check the pit to be sure that all clearing and grubbing has been done at the pit site, that all sod and other objectionable material has been removed, and that any required erosion control devices are in place. Project personnel should also be aware of the method of excavation the contractor is using. Soils in their natural state tend to be in layers. Additionally, drastic or unexpected changes in borrow material brought to the job site should be noted and monitored. This is necessary if problems occur during embankment construction. It will help isolate the areas that may need reworking.



Each layer, as shown in the previous cross section, may have different qualities. If the borrow pit is excavated horizontally, as with a scraper, the material can change as different layers are reached. Since a change in material can alter moisture and needed compactive effort, horizontal excavation requires close observation. It is better to excavate the material vertically through all layers with a dragline or a backhoe.

TRUE OR FALSE

4-33 True or False Material excavated to form side ditches and used for embankment construction is known as borrow.

4-34 True or False The inspector should check that sod and other objectionable material has been removed from the borrow pit site.

4-35 True or False When a borrow pit is excavated by scraper, the type of soil delivered to the roadway can change.

4-36 True or False A change in material can alter moisture and the amount of compactive effort required.

4-37 True or False It is better not to excavate a borrow pit through all layers.

4-42. true

After the fill material is on the roadway, a bulldozer or a motor grader will spread it. At this point, hand labor (root pickers) is needed to pick out objectionable material, such as clay balls, roots, stones, etc. This material is usually stacked on the roadway for later disposal.

4-43. false

4-44. true

The embankment material is spread across the roadway in layers (called lifts). Although exact grade is not required in early lifts, they should conform somewhat to the planned elevations and cross sections.

4-45. true

Each lift should consist of approximately 8 inches of loose material that yields approximately 6 inches when compacted.
Each lift should be placed across the full width of the embankment and be of uniform thickness unless otherwise specified by the plans or Specifications.

CIRCLE THE CORRECT ANSWER

4-38 The embankment material is spread across the roadway by a (scraper / motor grader).

4-39 Hand labor is used to (shape side slopes / pick out roots).

4-40 Each layer of embankment material is known as a (lift / elevation).

4-41 Each lift should be about (12 inches / 8 inches) thick before compaction.

Because proper moisture content is important in achieving required density, the contractor will adjust the moisture content of the soil.

If it appears too wet, he will disk it. By breaking up the soil, more surface area of the soil particles is exposed to the air, speeding up drying. This procedure is known as aeration.

If the material is too dry for proper compaction, a water truck can be used to increase moisture content. The spray bar on the truck should spray water evenly. The truck should not stop on the roadway with the water running, as this will cause a wet spot in the embankment.

If necessary, the material will then be disked, so that it is thoroughly blended.

The lift will be compacted with a sheepsfoot or a vibratory roller, just like the scarified embankment foundation.

When the contractor believes he has achieved the required density, he will request a density test to be taken. (Refer to the Sampling, Testing and Inspection Manual for frequency.)

Each succeeding lift is constructed in the same manner as the first. The sheepsfoot roller will leave the top surface of the lift roughened; therefore, the top 2 inches of lower lift may be compacted with the lift placed above it.

Compacting the top 2 inches of a lower lift with the succeeding lift also helps bind the two lifts together.

Before scheduling the density test, project personnel should visually observe the lift. Any areas that do not appear satisfactory must be corrected.

4-46. two

When checking the lift for uniformity, soft spots should be looked for. Soft spots can be identified by driving over the compacted lift with a heavy piece of equipment. As the wheels of the equipment enter a soft spot, the steering wheel will pull and the area will depress and spring back. Such soft spots are caused by material that is unstable or too wet.

4-47. sand cone, 12-inch ring, nuclear

If the material is unstable (e.g. an area of excessive clay content), it may be unusable in the embankment. In this case, stabilization with lime or cement may be required, or the unstable material may have to be removed by undercutting.

4-48. 95

If the area is wet, the situation may have been caused by inadequate drainage or by heavy equipment pumping moisture up from the subbase.

4-49. near optimum

For wet areas, the material must be dried by disking, lime stabilization, or by correcting improper drainage.

When the Inspector is certain that there are no obviously bad areas in the lift, he should request from the Lab that a density test be taken.

TRUE OR FALSE

4-50. true

4-42 True or False Any areas that are visually observed to the unsatisfactory must be corrected.

4-51. false

4-43 True or False Soft spots are caused only by moisture problems.

4-44 True or False To correct a soft spot, it may be necessary to remove the material in the area.

4-45 True or False Wet spots can be corrected by disking.

TESTING AND GRADE CHECKING

The Department has three approved methods of density testing.

Nuclear Gauge
12-inch ring
Sand Cone

These methods are explained in detail in the Department's Sampling, Testing and Inspection Manual. The nuclear gauge is the most common method used.

Density tests must be taken a minimum of once every 5,000 cubic yards. These sites should be selected randomly. The selected site should be representative of the entire area.

Because the upper 2 inches of the lift will not be compacted if a sheepsfoot roller is used, it must be cleared away before the density test is taken.

Unless otherwise specified, fills below the top 12 inches of the embankment must be compacted to 95% density. If tests indicate that this density has not been achieved, the contractor must continue his compactive efforts until the lift reaches 95% density.

Proper compaction is best achieved at near optimum moisture content; hence, if density has not been attained, information about moisture content can be helpful. Moisture checks are required. Moisture content for density tests should be determined by using the stove drying method. **The Speedy Moisture Device is not to be used.**

4-38. motor grader

4-39. pick out roots

4-40. lift

4-41. 8 inches

FILL IN THE BLANKS.

4-46 The top _____ inches must be cleared away before a density test is run, whenever a sheepsfoot roller is used.

4-47 The three methods of density testing approved by the Department are _____, _____, and _____.

4-48 Unless otherwise specified, fills are to be compacted to _____ % density.

4-49 Proper compaction is best achieved at _____ moisture content.

Project personnel should also check that the lifts are approximately the correct thickness. Embankment lifts should be uniform in thickness.

Grade, slope, and crown should be checked periodically, as the fill nears completion. Therefore, it is not necessary to check every lift.

TRUE OR FALSE

4-50 True or False Each lift of an embankment should be close to the same thickness.

4-51 True or False Grade, slope, and crown must be checked every lift.

4-56. true

4-57. true

4-58. insufficient

4-59. party chief

In order to check grade, first decide at which station it is to be checked. Then refer to the typical sections and/or the cross sections for that station.

If the final lift of the embankment is to be select material, the contractor will roll the preceding lift with a sheepsfoot, and leave the top 2 inches rough. Usually this lift will be ½ to 1 inch lower than plan grade, so that the proper amount of select material can be added.

If no select material is to be added, the contractor will bring the embankment to final grade. When the embankment is at final grade, blue tops must be set to grade, at the edge of the embankment.

The inspector should randomly check elevations, to be certain that they are accurate.

The contractor will fine-blade the material with a motor grader or fine grader to assure that grade and slope are uniform. The blade of the equipment will be set to cut material from high places and deposit it in low ones.

The last step in finishing an embankment is to roll it with a roller. It will seal the surface of the top lift and provide protection against weathering and traffic.

After the embankment is finished, final grade and crown must be checked using a string line and the blue tops, as explained earlier.

TRUE OR FALSE

4-52 True or False If the final lift of the embankment is to be select material, the contractor will leave the top 2 inches rough.

4-53 True or False The lift preceding a lift of select material is usually 2 inches below plan grade.

4-54 True or False When the embankment is at final grade, blue tops are set at the embankment edge.

4-55 True or False After the blue tops are set, the Inspector should check grade using a hand level and rod.

4-56 True or False To assure that grade and slope are uniform, the top of the embankment is fine bladed with a motor patrol.

4-57 True or False Rolling the top lift of an embankment with a pneumatic roller will protect it against weathering and traffic.

The side slopes of the embankment must also be ready for inspection. The Inspector must check their final slope ratio.

The Specifications in Subsection 208.04 says about FINAL FINISHING: "After all the embankment has been completed, the entire surface of the roadbed and the slopes shall be shaped to reasonably true grade alignment and Cross Sections shown on the Plans or established by the Engineer."

4-63. Suction dredge

4-64. clearing

FILL IN THE BLANKS.

4-65. within the right of way limits

4-58 If the slope line does not appear straight, but dips in a curve, there is an _____ amount of material in the embankment.

4-59 If the slope lines appear to be out of tolerance, the Inspector should be sure to notify the _____.

4-66. Standard Specifications

CUTS

Cuts refer to excavation made below the level of the natural ground.

Cuts are used for reaching grade when the elevation of the natural ground is above that of finished grade. They are also used for removing muck and for undercutting.

The plans will indicate which areas of a project are to be cuts.

In planning a roadway, designers often attempt to use balanced cut and fill. This means that the material excavated for ditches and other cut sections will provide exactly enough suitable material for fill sections.

All such unclassified excavation must be acceptable soils and must be free of objectionable material.

Any material which is not suitable for fills or which is not needed for fill construction must be wasted outside the right-of-way.

Excavation areas where the material is known to be unsuitable for embankment construction will be indicated on the plans. Project personnel should observe the material being excavated. If it appears to be unsuitable for embankment construction, he should notify the Project Engineer and the District Materials Engineer.

Grade and slope for embankments apply to cuts as well as fills. The procedures for checking grade and slope will be the same.

FILL IN THE BLANKS.

4-60 Excavations below the natural ground level are known as _____.

4-61 When the material excavated provides exactly the amount of suitable material needed for fill sections, the designers have planned for _____ cut and fill.

4-62 Excavation material not used for fills must be wasted outside the _____.

4-52. false

4-53. false

4-54. true

4-55. true

4-72. material too dry, drum too light

4-73. moisture content and compactive effort

4-74. 8 inches of loose material

4-75. two inches

4-76. too dry material, mix material

REVIEW QUESTIONS

Check the correct answer(s).

4-63 Which of the following equipment is used for hydraulic excavation?

a. crawler tractor

b. suction dredge

c. motor grader

d. backhoe

4-64 The removal of trees, brush, and boulders is referred to as:

a. clearing

b. compacting

c. grubbing

d. stripping

4-65 The Standard Specifications require the entire construction area to be cleared and grubbed to a point:

a. 5 feet beyond the toes of the front slopes/tops of backslopes

b. 5 feet beyond the shoulders

c. 5 feet beyond the right-of-way

d. within the right-of-way limits

4-66 Rules that apply to burning vegetation that has been cleared are given in:

a. OSHA Handbook

b. Standard Specifications

c. Construction Manual

d. Regulations of the Georgia Air Control Commission

4-67 All stumps, roots, and nonperishable solid objects must be removed to a minimum of _____ below subgrade.

a. 24 inches

b. 10 inches

c. 12 inches

d. 2 inches

4-68 To measure the depth of scarification, the inspector should:

a. brush away the top 2 inches to allow for fluff

b. measure against the original ground level

c. measure in the center of the roadway

d. measure after the scarified area has been recompacted

4-69 If the soil of the scarified area differs in composition from that of the surrounding area, what should the Inspector do when checking the density of the recompacted area?

a. Make a proctor for each site and check the percent compaction.

b. Check the compaction against the nearest area of similar soil

c. Disregard the difference in soils, since only the approximate density is required.

d. Use a nuclear device.

4-70 If the material being compacted by a sheepsfoot roller is too dry:

a. mud will collect between the feet

b. roller weight must be increased

c. roller weight must be decreased

d. bridging will occur

4-71 With each pass, the feet of a sheepsfoot roller will:

a. penetrate more and more

b. penetrate less and less

c. fluff the soil more

d. stay the same

4-60. cuts

4-61. balanced

4-62. Right of Way

4-82. roller

4-83. blue tops and a stringline

4-72 Which of the following will cause a sheepsfoot roller to walk out too soon?

a. material too dry

b. material too wet

c. drum too heavy

d. drum too light

4-73 A change in soil can affect:

a. moisture content and compactive effort

b. moisture content only

c. moisture content and method of spreading

d. the moisture in the erosion control devises

4-74 Each lift of an embankment should consist of:

a. 8 inches of loose material

b. 12 inches of compacted material

c. 10 inches loose material

d. 6 inches of compacted material original ground level

4-75 The top _____ of a lift can generally be compacted with the succeeding lift.

a. 6 inches

b. ½ inch

c. 1 inch

d. 2 inches

4-76 Disking is used:

a. to compact shallow lifts

b. to dry material

c. to mix material

d. to reduce lift thickness

4-77 Which of the following is not a possible cause of soft spots?

a. over compaction

b. unstable material

c. improper drainage

d. material too wet

4-78 Which of the following is not an approved method of density testing?

a. Nuclear device

b. sand cone

c. 12-inch ring

d. Ottawa test

4-79 Density tests must be taken a minimum of:

a. one per 100 feet

b. one per 5,000 y^3

c. one per 500 feet

d. five per 1,000 feet

4-80 Fills must be compacted to _____ density, unless otherwise specified.

a. 98%

b. 90%

c. 95%

d. 80%

4-81 After blue tops have been set, the inspector should use a _____ to check grade.

a. level and tripod

b. hand level

c. slope template

d. hard hat

4-67. 24 inches

4-68. measure against the original ground level

4-69. make a proctor for each site and check percent compaction

4-70. bridging will occur

4-71. penetrate less and less

4-82 To protect the top of the embankment against weathering, a _____ is used.

a. roller

b. motor grader

c. vibratory roller

d. steel-wheel roller

4-83 Final grade and crown are checked with:

a. a hand level and slope template

b. a rolling straightedge

c. level and tripod

d. bluetops and a stringline

5-1. 15%

5-2. vegetation will absorb and hold water and decay

5-3. mushy or swampy

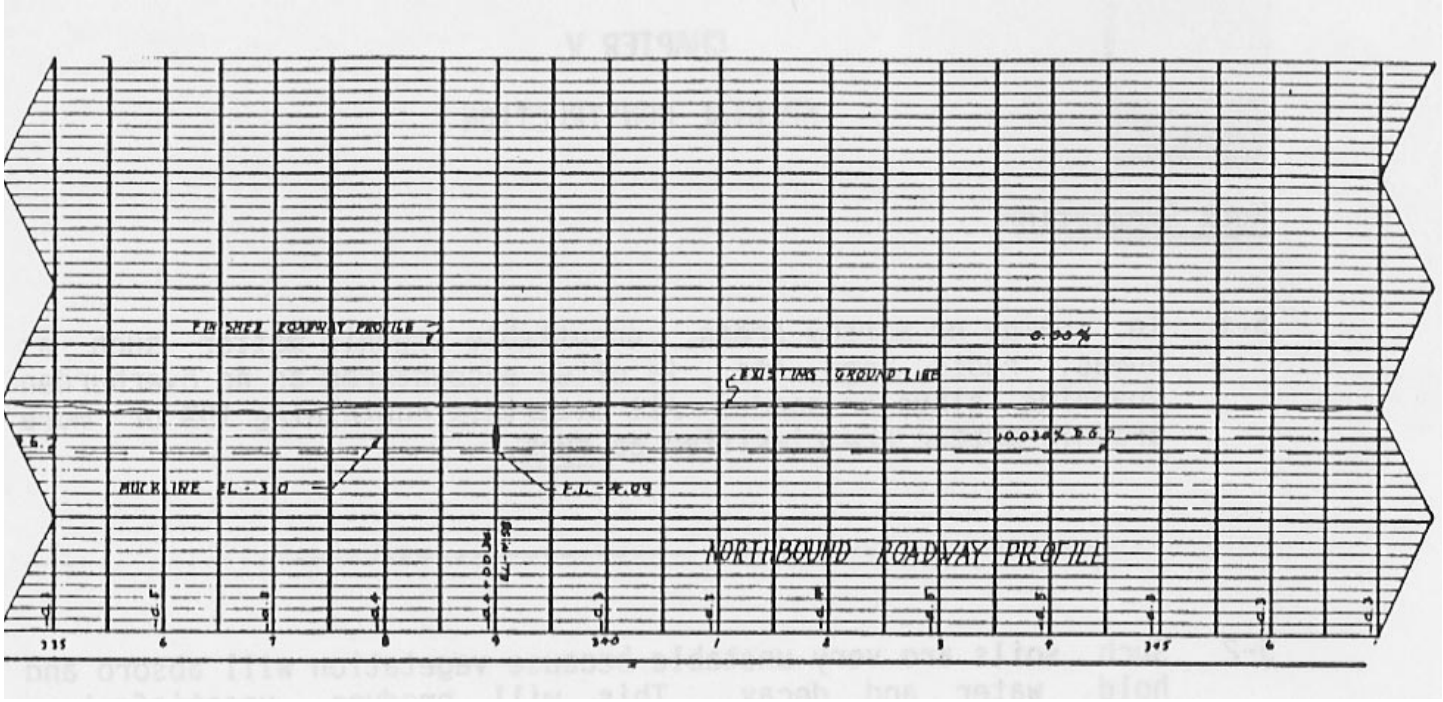
CHAPTER V

Special Construction/Muck Excavation

In swampy or marshy areas, unsuitable organic matter such as humus, roots, logs, etc., is often encountered as an overburden covering clays or sands. All materials containing 15% or more organic matter are classified as muck.

Such soils are very unstable because vegetation will absorb and hold water and decay. This will produce unsatisfactory subsidence (sinking) in the embankment; therefore, muck is usually removed and replaced with satisfactory material. The process of removing such material is known as muck excavation or mucking.

In areas where sections of the project cross marshy or swampy land, the muck line, determined from soil borings, may be indicated on the plans. Refer to the following example.



4-77. at over compaction

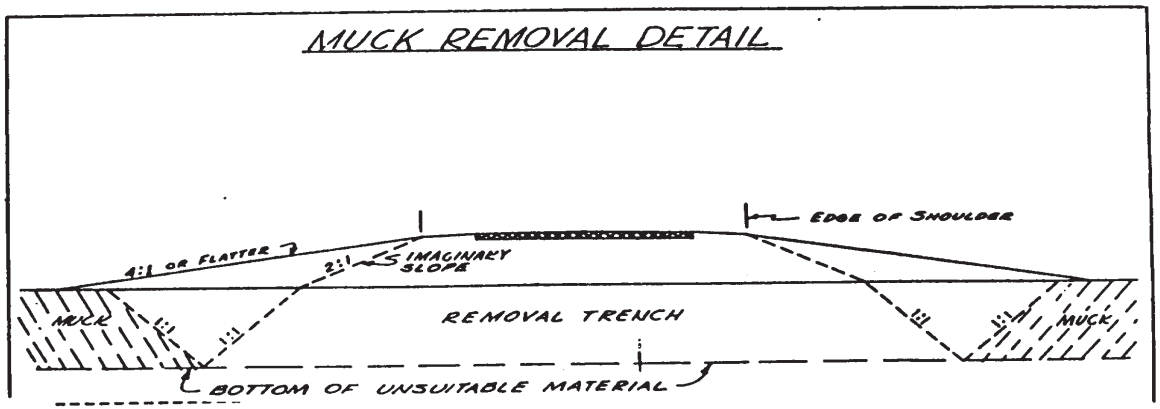
4-78. Ottowa Test

4-79. One per 5,000 cubic yards

4-80. 95%

4-81. level and tripod

In other cases, only a typical muck excavation section will be shown.



5-8. false

Material should be removed to the depth indicated on the plans or deeper, if necessary. Regardless of the amount of detail regarding muck excavation incorporated in the plans, the Inspector must carefully observe the material being excavated, to be certain that all muck is removed.

5-9. true

Occasionally, muck will be encountered unexpectedly on a project. If it is a small area, the Engineer advises the contractor to remove it and the work is paid for as unclassified excavation. If it is a large area, the laboratory should be notified, so that borings can be made to determine the limits of the muck.

5-10. true

After the extent of the muck has been ascertained, a Plan Change and/or Supplemental Agreement may be necessary in order to complete the work.

5-11. false

FILL IN THE BLANKS

5-12. true

5-1 Muck contains _____ percent or more organic matter.

5-2 Soils containing muck are unstable, because _____.

5-3 Muck is usually found in areas of _____ or _____ land.

5-4 The Inspector must observe the material being excavated to be certain that _____.

5-5 If muck is encountered unexpectedly on a project, a _____ may be necessary in order to complete the work.

Muck excavation is usually paid for by the cubic yard; hence, the amount excavated must be carefully measured. Such determinations are usually made by cross sectioning the area both before and after mucking.

For areas in which the water is too deep for the use of conventional methods of taking cross sections, probing with a graduated rod will be required.

When mucking operations are completed, the Inspector should notify the Project Engineer, so that cross sections can be made.

TRUE OR FALSE

5-6 True or False Muck excavation is paid for by linear measure.

5-7 True or False Areas of muck excavation must be cross-sectioned before and after operations.

UNDERCUTTING

Undercutting involves removing soft or spongy material from the embankment area. It differs from mucking in that material removed by muck excavation is organic, hence not acceptable for use in the embankment under any circumstances. The material removed by an undercutting operation may sometimes be suitable for an embankment if it is simply too wet.

Undercutting can be used to remove soft spots in the embankment or subgrade. Undercutting operations are usually not anticipated. Hence, if a need for undercutting becomes apparent, the Project Engineer should be notified immediately.

If the unsatisfactory area is extensive, the laboratory should be contacted, so that borings can be made to determine the amount of undercutting that is needed.

Since undercutting involves material that is useable in the embankment, the contractor may choose to allow the material to dry, then reuse it in the embankment. However, because of the length of time required to dry such material, the contractor will usually elect to refill (backfill) the excavated area with new material.

After being backfilled, the area must be recompacted to the required maximum density and a density test taken.

If select material has been specified, samples must be taken in accordance with the sampling frequency specified in the Plan Change and/or Supplemental Agreement.

Pay quantities are based on a specified neat length, width, and depth.

TRUE OR FALSE

5-8 True or False Removing soft organic material from the embankment area is known as undercutting.

5-9 True or False Undercutting operations are not usually anticipated.

5-10 True or False When the unsatisfactory area is extensive, the laboratory may need borings to ascertain the amount of undercutting needed.

5-11 True or False Material that has been removed by undercutting can never be reused in the embankment.

5-12 True or False The neat length, width, and depth of the excavated area are used to determine pay quantities for undercutting.

EMBANKMENTS CONSTRUCTED WITHOUT DENSITY CONTROL

When an embankment must be constructed over a large area of soft, unstable soil, such as a marsh or where the area is under water, it may be necessary to build the embankment without density control.

Ditches, if required, must first be excavated to help with drainage during construction.

Generally, fill material will be placed and spread across the embankment area in layers.
A crown must be maintained during the fill operation to assure adequate drainage.

After the fill has reached the elevation specified on the plans, the top layer (12 inches) is compacted to a minimum of 100% density.

All lifts that follow will be constructed with density control.

TRUE OR FALSE

5-13 True or False Embankments built over marshy areas are often constructed with no density controls.

5-14 True or False The maintenance of a crown and the excavation of ditches are essential to proper drainage during construction.

5-15 True or False Lifts no thicker than 9 inches are used to construct embankments that do not have density controls.

5-16 True or False The top layer of such embankments must be compacted to a minimum of 100% density.

5-17 True or False After the top layer is checked for density, all subsequent lifts must be constructed with density controls.

5-4. All muck is removed

5-5. Plan change and a Supplemental Agreement

5-6. False

5-7. True

5-23. false

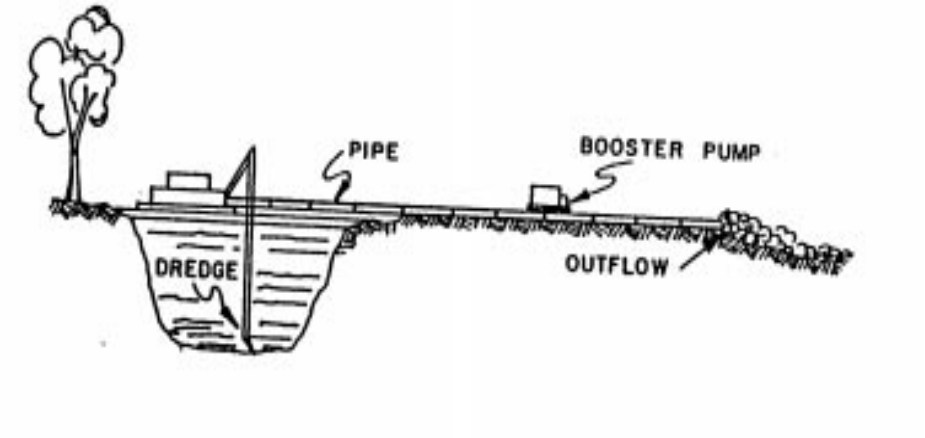
5-24. false

5-25. false

HYDRAULIC EMBANKMENT

Hydraulic embankments are constructed by pumping embankment materials (usually granular material, such as sand) from a body of water onto the prepared embankment foundation.

This procedure is accomplished by means of dredging operation. A dredge is set up in a waterway or a flooded borrow pit. The dredge sucks the material and water from the bottom of the borrow area into a pipe through which it is transported to the embankment area. Booster pumps may be located along the pipeline.



The dredging area must be located at least 500 feet from the toe of the embankment slope, unless otherwise allowed by the plans or special provisions.

Before pumping for the embankment begins all unsatisfactory material, such as muck and debris, must be removed from the borrow area.

The material being dredged often lies in layers. The Inspector must be familiar with the boring reports of the area and cannot allow unsatisfactory material to be pumped into the embankment. Should any unacceptable material be pumped into the embankment area, it must be removed by dragline or other satisfactory methods.

FILL IN THE BLANKS

5-18 _____ is a material that might be used to construct an embankment by hydraulic methods.

5-19 A _____ is used to excavate the embankment material from a nearby waterway.

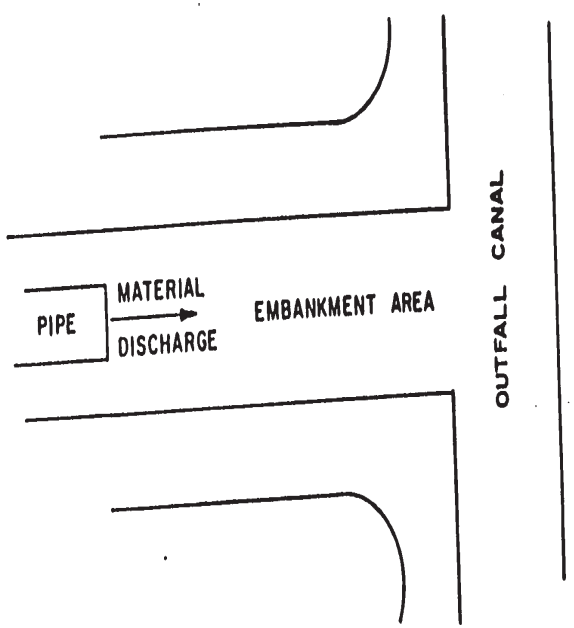
5-20 The dredging area must be located a minimum of _____ feet from the toe of the embankment slope.

5-21 The Inspector should be familiar with boring reports so that he can anticipate when layers of _____ might be pumped into the embankment.

5-22 Should muck be inadvertently pumped into the embankment area, it must be _____.

The embankment area for a hydraulic fill is first cleared and grubbed, then excavated to the foundation grade required on the plans. Because the materials used in hydraulic embankment are mixed with water and are usually granular, they must be confined within the limits of the embankment. Levees of highly plastic material, such as clay, are constructed to maintain the embankment during construction.

See the following illustration.



5-13. true

5-14. true

5-15. false

5-16. true

5-17. true

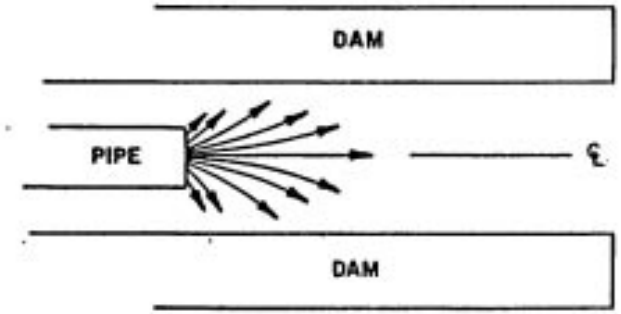
TRUE OR FALSE

5-23 True or False Embankment areas for hydraulic fill do not require clearing and grubbing.

5-24 True or False Levees of a highly plastic material must be used to confine the hydraulic fill within the embankment area.

5-25 True or False After embankment construction is complete, the slopes are dressed with 6 inches of highly plastic soil.

The material is usually discharged along the centerline. It will then spread to the sides and ahead of the discharge line.



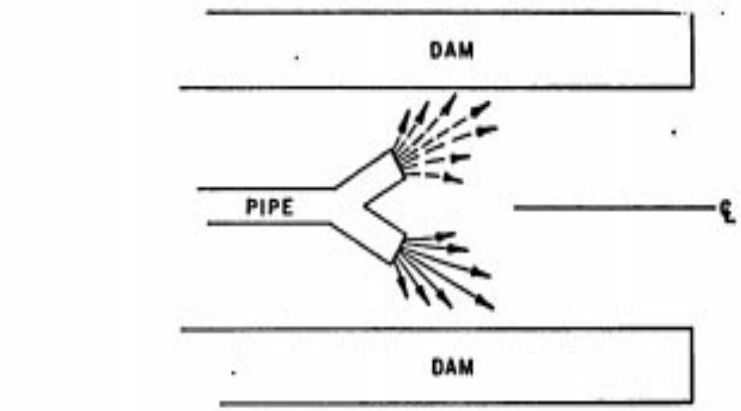
5-30. surcharge

5-31. ground beneath the embankment

5-32. time period

When the area reached by the current pipe placement is full, another length of pipe is attached and material pumped into the next section. This process is repeated until the entire length of the embankment is finished.

On the wide roadways (i.e. 4-lanes), a wye joint may be used. In this case the material is discharged approximately halfway between the centerline and each edge of the embankment.



However, when this method of material placement is used, only one pipe should discharge material at a time to prevent muck, from either the foundation or discharge material, from being trapped in the embankment.

Muck will usually flow in front of the discharge and be carried off the embankment into the out fall canal.

The Inspector must observe the discharge area carefully, so that no objectionable material will be trapped in the embankment. Muck or other unacceptable material can float up from the embankment foundation or be pumped in through the pipeline.

The material should always be placed so that a higher elevation is maintained in the center of the roadway. This procedure will allow the material to drain, as well as causing the embankment to naturally conform to the cross section shown on the plans. However, the center should not be allowed to build up into a cone.

TRUE OR FALSE

5-26 True or False When single pipe is used, the material is discharged along the centerline.

5-27 True or False On a four-lane roadway, the material would be discharged along the shoulders of the embankment.

5-28 True or False Muck will usually flow in front of the discharge and be carried into the outfall canal.

5-29 True or False So that the embankment can be easily bladed to the proper cross section, the center of the roadway should be built into a cone.

5-18. sand

5-19. dredge

5-20. 500 feet

5-21. unacceptable material

5-22. removed

5-36. A, B, C

Most hydraulic embankments are built with a surcharge. The term surcharge means that more material is placed over the foundation than will be required for the finished embankment. The weight of the extra material causes the ground beneath the embankment to settle, so that no shifting or settling, detrimental to the completed roadway, will occur after the pavement is in place.

5-37. A

The surcharge material remains in place for a period of time specified in the plans and/or contract. After this time has elapsed, the extra material is removed and disposed of outside the limits of the right-of-way. The embankment is then brought to grade.

5-38. A, B

FILL IN THE BLANKS

5-39. C

5-30 Extra material placed in the embankment above the required finished grade is known as a _____.

5-40. A and B

5-31 Surcharges are used to cause the _____ to settle.

5-32 Surcharge material is removed and disposed of after a _____ specified in the plans and/or contract.

The water that carries the embankment material will gradually seep out. This action causes the embankment materials to compact to some degree throughout. The plans will indicate the elevation at which compaction operations and density control will begin. Usually density tests are performed on only the top 12 inches after the surcharge has been removed.

The contractor must take all necessary precautions to prevent blocking existing streams or waterways, or filling them with soil or debris.

Dikes, berms, and other types of levees may be needed during hydraulic construction for drainage, pondage, or other forms of water control. However, in no instances, may the contractor construct restraining levees along highways.

CIRCLE THE CORRECT ANSWER.

5-33 The seepage of water out of the embankment material causes the material to (compact / shift).

5-34 The (plans / Standard Specifications) indicate the elevation at which compaction operations and density control are to begin.

5-35 The contractor is not allowed to build (ponds / restraining levees) along highways.

LIME TREATMENT

Lime may be applied to subgrade or embankment soils. It is used to improve them, to lower their Plasticity Index, or to dry the soil more rapidly, so that construction operations can proceed.

The Specifications provide for three different types of lime treatment as delineated by the following table from Subsection 225.01.

SECTION 225 – SOIL-LIME CONSTRUCTION

225.01 DESCRIPTION: This Work shall consist of preparing and treating with lime, the existing roadbed materials, or materials to be placed to form a
subgrade, subbase or base in accordance with Plan details. It shall include watering, mixing, shaping, and compacting the necessary material in accordance with the requirements specified herein and to the lines, grades, and thicknesses as shown on the Plans. The requirements of these Specifications are applicable to each course or layer, except as otherwise indicated on the Plans or as h erein specified.

Lime treated roadbed materials, subbases or bases will be designated as Class A, Class B, or Class C.

CLASS A LIME TREATMENT: Class A Lime Treatment shall consist of spreading and incorporating the specified percentage of lime in 2 approximately equal increments in the following sequence: Spreading the first increment, initial mixing, mellowing; spreading the second increment, final mixing, compacting and finishing in accordance with these Specifications. Mellowing is defined as the process of softening to a loamy consistency.

5-26. true

5-27. false

5-28. true

5-29. false

CLASS B LIME TREATMENT: Class B Lime Treatment shall consist of spreading the specified percentage of lime, initial mixing, mellowing, final mixing, compacting and finishing in accordance with these Specifications.

CLASS C LIME TREATMENT: Class C Lime Treatment shall consist of spreading the specified percentage of lime, mixing, compacting and finishing in accordance with these Specifications.

FILL IN THE BLANKS

5-36 Type _____, _____, and _____, lime treatment can be used on subgrade soils.

5-37 Type _____ requires two applications of lime.

5-38 Curing is required for type _____ and _____.

5-39 Type _____ does not require a mellowing period.

5-40 Type _____ are designed primarily for embankment construction.

When Type A, B, or C lime treatments are specified, the subgrade, or the layer to be treated, should be brought to proper grade and alignment. Grade and alignment are not usually as critical for Type A or Type B and are often not required. Because some soils, such as heavier clays, tend to "fluff" (increase in volume) with lime stabilization, it may be necessary to lower the subgrade elevation slightly to compensate for this tendency.

"Fluffing" becomes less of a problem when soils are kept at optimum moisture content.

Maintaining the soil at the proper moisture level is extremely important for all types of lime treatment, because the presence of water is necessary for the lime to react chemically with soil elements. Without water, the lime will not react effectively; hence, the soil should be damp during liming operations.

TRUE OR FALSE

5-41 True or False Lime should be applied to subgrade soils before the subgrade is brought to grade.

5-42 True or False Heavier clays tend to fluff with lime treatment.

5-43 True or False Soil should be kept damp during all lime treatments.

Lime can be applied either dry or in slurry form. Dry lime can be applied by bulk transport or by bag. Economics usually dictate, however, that bulk transport be used.

The increased expense and amount of handling required by bagged lime make this procedure impractical for any but small jobs. Although bagged lime greatly reduces the amount of dust generated by the liming operation, and in the past was often preferred for jobs in urban areas, the advent of lime slurry using guidelines for hydrated lime is now preferred for urban areas.

For bagged lime application, bags of lime are placed at regular intervals along the area to be treated. Each bag is then slit by hand and the lime dumped into piles or windrows. It is then spread evenly using either hand-held rakes or other suitable mechanical equipment. The lime is then cut in and the soil pulverized in the same manner as lime that has been applied by bulk transport.

TRUE OR FALSE

5-44 True or False Lime can be applied either dry or in slurry form.

5-45 True or False Bagged lime application is not recommended in urban areas because of the dust level created.

5-46 True or False Each bag of lime must be slit by hand and the lime dumped into windrows or piles.

5-47 True or False The slit bags are shaken by hand to spread the lime evenly on the ground.

5-33. compact

5-34. plans

5-35. restraining levels

There are several types of bulk transport that can be used for lime distribution. Most contractors use some type of self-unloading transport capable of spreading the lime easily.

Bulk transport trucks are usually equipped with a pneumatic pump and a spray bar. The lime is blown through the spray bar at the back of the truck, as it is driven over the prepared soil.

Regardless of the type of bulk transport used, more than one pass may be necessary to apply the proper amount of lime to the surface. When there is a brake between Stations of lime distribution, the Inspector must make certain that no section of roadway is left without lime treatment. It is preferable to overlap sections, than to have an area left untreated. Careful attention should be paid to such areas when sections are staked with distribution markers.

No type of application can prevent dry lime from blowing on windy days. The Project personnel should not allow lime to be placed on the roadway when wind conditions may cause excessive blowing. Blowing lime creates both a health hazard and causes a loss of lime from the roadway.

To be certain that the correct weight of lime, as specified in the contract, is being applied to the roadway, the Inspector should have the distributor pass over a box one square yard in size. By subtracting the weight of the empty box from the weight of the box and lime, the Inspector can ascertain how many pounds of lime are being placed per square yard. If the amount is not sufficient, the Inspector should instruct the contractor to make appropriate adjustments.

DISTRIBUTING LIME

Immediately following the placement of lime on the roadbed, it is cut into the soil to the proper depth by a disk. This disking mixes the lime and soil, leaving large clods.

CLODS

After the lime has been cut in, the area is turned by a motor grader and lightly compacted by a pneumatic roller. This will minimize the amount of lime loss in the event of rain or through carbonization.

The limed roadbed is then remixed with mixers that pulverize the material to proper sieve requirements The soil material should be at optimum moisture content during this operation. If necessary, water can be added through the mixers.

Mixers are self-propelled or tractor-drawn machines equipped with blades to cut and mix the soil. Generally, the larger the machine, the more sets of blades it will have. The blades rotate in different directions, assuring complete mixing of the soil particles. In most cases, fewer passes will be needed by a many-bladed machine to achieve proper pulverization.

5-41. false

5-42. true

5-43. true

5-44. true

5-45. false

5-46. true

5-47. false

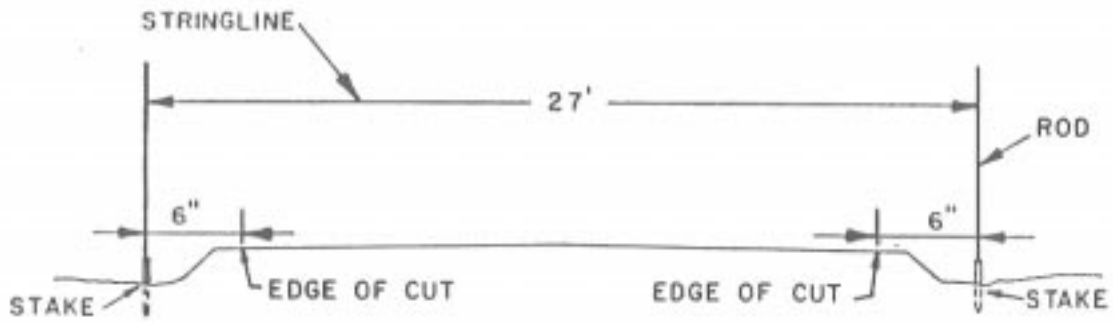
The depth of pulverization is checked by the Inspector for project control, prior to any compaction. These checks should be made in accordance with GDT 42 of the Sampling, Testing and Inspection Manual by project personnel.

GDT 42 says these depth measurements are to be taken at a minimum of one per 1,500 feet per two lanes per lift. Three holes are dug across the roadway at each location and one on each shoulder. These measurements must be recorded in a field book by Station and location.

The depth check is made by digging a hole with a posthole digger or a hand auger, to the bottom of the cut made by the stabilizer. A straightedge or a stringline is then placed at a known elevation (or other suitable reference) and a measurement taken with a ruler to the bottom of the cut.

Width measurements are taken at the same location as depth checks. They must represent the actual width that is cut and mixed. Usually width checks for project control are made while the mixers are still operating, prior to any compaction procedures.

To check width, the Inspector must find the exact edge of the cut. He does this by scooping away the pulverized material, so that he can locate the edge of the uncut material. If an erected stringline is being used, measurement can then be made from the edge of the cut to the rod. These measurements are made on each side of the roadway. Then the combined distances are subtracted from the distance between the rods.



The preceding diagram shows a cut section 24 feet wide.

CIRCLE THE CORRECT WORD(S)

5-48 When lime is distributed by bulk transport, the lime is often blown through the (pneumatic pump / approved spreader) located at the back of the truck.

5-49 It is extremely difficult to get even lime distribution with a (spray bar / bottom dump truck).

5-50 When there is a break between Stations marked for lime distribution, it is better to allow the areas to (overlap / break).

5-51 Applying lime in a high wind is an (acceptable / unacceptable) construction practice.

5-52 A (disk / mixer) will mix lime and soil, leaving large clods.

5-53 A (pneumatic roller / mixer) is used in an operation designed to cover the lime to prevent its loss due to rain or carbonation.

5-54 A (mixer / disk) is used to pulverize the lime/soil mixture to proper sieve requirements.

5-55 During pulverization the lime/soil mixture should be kept (dry / at optimum moisture content).

5-56 The depth of pulverization is checked by the Inspector prior to compaction for (project control / acceptance).

5-57 Depth checks are taken in accordance with (GDT 42 / GDT 21).

5-58 (Three / Two) holes are dug across the roadway to check depth.

One of the goals of lime operation is to make clay friable (easily crumbled); hence, proper pulverization is important. Because lime does not penetrate clay, the lime must come into contact with enough particles for it to react effectively with the soil. The Standard Specification require that for Types A, B, and C treatment, the pulverized lime/soil mixture, exclusive of stone or other aggregate, must pass a 3 inch sieve.

The testing procedure for pulverization of soil/lime mixtures is delineated by GDT 51 of the Testing Manual.

As soon as proper depth and sieve size has been achieved, the section is compacted by a sheepsfoot roller until density specifications are met. The roadbed is then sealed by a pneumatic roller. Following compaction, the roadway will be allowed to cure in accordance with the requirements of the contract and Specifications.

5-69. true

When the contractor believes that he has achieved the required density, density tests must be taken in accordance with GDT 20, 21 or 59 of the Testing Procedures Manual. One test must be taken for each 1,500 feet per two lanes.

5-70. true

At the same time the density is checked, thickness and width of the completed course should be checked. These measurements should be made in accordance with GDT 42 of the Testing Manual.

5-71. true

The tests for thickness and width taken by project personnel are used for project control only. Acceptance testing is performed by the Branch Laboratory.

The depth measurements made after compaction should be taken at the same Station as those taken prior to compaction. The same procedure is followed in checking depth. When no erected stringline is available on the job, establishing the elevation of the stringline or straightedge for checking depth may be difficult. In this case, phenolphthalein can be used to establish the depth of the lime treatment. Phenolphthalein is a chemical that turns bright red in contract with alkalis such as lime.

To check depth, the phenolphthalein is squirted down the side of the hole. The point where the red color stops indicates the bottom of the lime/soil mixture. Measuring from that point to the top of the compacted roadway will indicate the thickness of the lime/soil mixture.

The Specifications specify tolerance for under thickness or underwidth. The depth of the lime treated area must be within 1 inch of plan thickness. Overthickness will be waived at no additional cost to the Department.

All measurements for width and thickness should be recorded in a field book by Station.

TRUE OR FALSE

5-59 True or False Friable means easily crumbled.

5-60 True or False Following pulverization, the allowable percent of soil passing the 3-inch sieve is 50%.

5-61 True or False The testing procedure for pulverization for soil/lime mixture is GDT 51.

5-62 True or False Prior to curing, the roadbed is sealed with a sheepsfoot roller.

5-63 True or False One density test is required for each 200 feet of roadway.

5-64 True or False The District Laboratory will make thickness and width measurements for acceptance.

5-65 True or False Phenolphthalein is a chemical that turns red in the presence of dirt.

5-66 True or False The difference between the actual thickness of the lime treated area and the thickness specified on the plans can be no greater than 1 inch, unless the actual thickness is greater than that specified by the plans.

5-67 True or False Overwidth carries a 90% payment penalty.

5-68 True or False All thickness and width measurements should be recorded in a field book by Station location.

5-48. approved spreader

5-49. bottom dump truck

5-50. overlap

5-51. unacceptable

5-52. disk

5-53. pneumatic roller

5-54. mixes

5-55. at optimum moisture

5-56. project control

5-57. GDT42

5-58. three

5-76. The material excavated would be reusable if dry

5-77. undercutting

5-78. meet 95% density

5-79. hydraulic embankments

5-80. at the centerline

CEMENT TREATMENT (STABILIZATION)

There may be occasions when the roadbed soil will be treated with cement instead of lime.

The procedures for cement stabilization are essentially the same as for lime treatment.

For cement treatment the area being treated is first broken up by disking, and brought to optimum moisture. Then the cement is applied. The soil/cement mixture is then pulverized by stabilizers and compacted.

The most important difference between lime and cement treatments is that in the case of cement treatment, all mixing and compacting must be completed within two hours after the initial mixing of the cement and soil.

If more information about cement stabilization is required, refer to the Department's training course Base Course Inspection.

TRUE OR FALSE

5-69 True or False Cement can be used for subgrade treatment.

5-70 True or False All mixing and compacting operations must be completed within two hours of the initial mixing of soil and cement.

5-71 True or False Cement stabilization is discussed in the Department's training course Base Course Inspection.

REVIEW QUESTIONS

Check the correct answer(s).

5-72 All soils containing 15% or more organic matter are classified as:

a. select material

b. muck

c. unclassified excavation

d. borrow

5-73 Muck is:

a. removed

b. covered with shell

c. used in the top of the embankment

d. covered with sand

5-74 If muck is encountered unexpectedly on a project:

a. the laboratory should be notified

b. excavation should be begun immediately

c. lime treatment should be started

d. it should be stabilized with cement

5-75 Muck excavation is paid for by:

a. vehicular measure

b. tons

c. cubic yards

d. plan quantity

5-59. true

5-60. false

5-61. true

5-62. false

5-63. false

5-64. true

5-65. false

5-66. true

5-67. false

5-68. true

5-86. GDT 42

5-87. easily crumbled

5-88. phenolphthalein

5-76 Undercutting differs from mucking in that:

a. the machinery used is different

b. the material excavated would be useable if dry

c. undercut material is removed from borrow pits

d. undercutting is always designated on plans

5-77 _____ can be used to remove soft spots in an embankment or a

a. subgrade.

b. backfilling

c. borrow excavation

d. undercutting

5-78 All layers of embankment (except the top 12 inches):

a. must meet 90% density

b. do not require density tests

c. must meet 95% density

d. must be compacted to 6 inches or less in thickness

5-79 Embankments constructed by pumping fill material from a body of water are called:

a. hydraulic embankments

b. rock fills

c. muck excavation

c. undercut embankments

5-80 The Inspector should be certain that the pumped material maintains a higher elevation:

a. at the shoulder line

b. near the outfall canal

c. just in front of the pipe

d. at the centerline

5-81 Extra material placed on a fill to cause the ground beneath the embankment to settle is called:

a. muck

b. borrow

c. surcharge

d. hydraulic embankment

5-82 Which of the following would justify lime treatment?

a. soil PI too high

b. soil too dry

c. silty soil that erodes

d. muck

5-83 Which type of lime treatment is specified for a working table?

a. A

b. B

c. C

d. D

5-84 Lime slurry application is more practical:

a. when the wind is gusting above 40 mph

b. on large jobs

c. in urban areas

d. when the soil is particularly wet

5-85 _____ are used to pulverize the soil/lime mixture to the proper sieve size.

a. disks

b. bulk transports

c. hand-held rakes

d. mixers

5-72. muck

5-73. removed

5-74. the lab should be notified

5-75. cubic yard

5-86 Thickness and width measurements for lime treatment should be done in accordance with:

a. GDT 42

b. GDT 24

c. GDT 40

d. GDT 101

5-87 Friable means:

a. easily crumbled

b. dry

c. the soil contains organic matter

d. wet

5-88 A chemical that turns red in the presence of lime is:

a. lye

b. phenolphthalein

c. cement

d. carbonization

CHAPTER VI

Documentation

Record keeping is an important and necessary part of project records. There are several departmental documents that you will have to maintain as a part of the project record.

The Construction Manual, in section III-4, states: "Project records must contain the actual facts of construction. The records must be kept current and complete. The records must be neat, legible, well organized, and concise. The project records must show the Project Number and County. The calculation methods used, the signature of the person(s) preparing or certifying the record, and the date and location (Station). Work or material which does not meet Specifications or contract requirements must be noted on the source document on an exception basis."

Source Documents

Source documents are those that constitute evidence that work was done and done in compliance with the contract and Specifications. These records are the foundations upon which the Department bases its payments to the contractor and serve as legal support in the event of a court action. It is such records, and not construction reports and statements that determine when and how much a contractor will be paid.

Not all documents you will be working with constitute "source documents" for the project. However, those that are, include:

DOT Form 627-10 (Inspector's Report)
Load Tickets
Field Books

Field Books that contain earthwork quantities are an acceptable alternative source document to the Inspector's Report. When the source records are kept in Field Quantity Books, the information is required in the Inspector's Report for each pay item. When practicable, the Field Books should be kept in the project office to prevent loss.

5-81. surcharge

5-82. Soil P.I. too high

5-83. A

5-84. In urban areas

5-85. mixers

Inspector's Report

According to the Construction Manual, a 627-10 is required whenever project personnel makes measurements for payment of stockpiles, certifying partial payment quantities, and when measuring for the final payment upon completion of the excavation and/or embankment work.

A sample 627-10 is shown as follows:

C2-98

DEPARTMENT OF TRANSPORTATION
Division of Construction
Inspectors Report

Report No. _____

Project No. _____ County _____

Contractor or Subcontractor _____

Date(s) Work Accomplished _____

☐ Estimate Only
☐ Source Document
☐ See Qty Book No. _____ Page _____
☐ See Back or Attachment

L.I.N. _____ Item Number 205 - _____ _____

STATION TO STATION OR LOCATION	PLAN QUANTITY	ESTIMATE % COMPLETE			PAY QUANTITY
		TOTAL TO DATE	LAST PERIOD	THIS PERIOD	CUBIC YARDS ESTIMATED

TOTAL _____ CU.YD.

Material Source _____
& Test Certification _____
Remarks: _____
Inspector's Signature _____ Title: _____

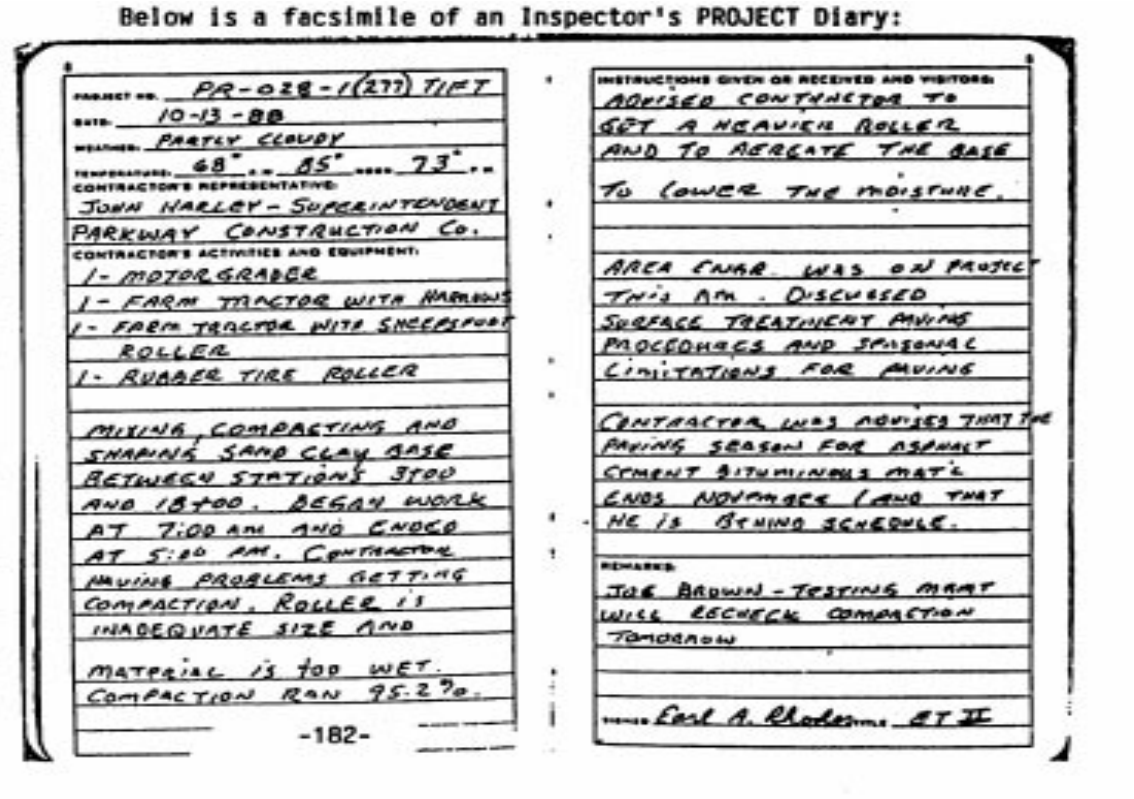
Audited By: _____ Date _____ Total To-Date _____ Monthly Total _____
Comments: _____ Constr. Rpt. No. _____ Dated _____
_____ Recorded for Payment By: _____

Inspector's Diaries

Inspector's diaries are intended to supplement the CONTRACT DIARY* on projects where the amount of detailed information is greater than can be accommodated in the Contract Diary.

*The Contract Diary is a daily record of the construction activity and time changes on the project…primarily, the Contract Diary is the source record of working conditions and work performed…it is maintained by the engineer in charge of the project!

Below is a facsimile of an Inspector's PROJECT Diary:



PROJECT NO. PR-028-1(277) TIFT
DATE: 10-13-88
WEATHER: PARTLY CLOUDY
TEMPERATURE: 68° 8 AM 85° NOON 73° 5 PM
CONTRACTOR'S REPRESENTATIVE:
JOHN HARLEY - SUPERINTENDENT
PARKWAY CONSTRUCTION CO.
CONTRACTOR'S ACTIVITIES AND EQUIPMENT:
1 - MOTOR GRADER
1 - FARM TRACTOR WITH HARROWS
1 - FARM TRACTOR WITH SHEEPSFOOT ROLLER
1 - RUBBER TIRE ROLLER

MIXING, COMPACTING AND SHAPING SAND CLAY BASE BETWEEN STATIONS 3700 AND 18+00. BEGAN WORK AT 7:00 AM AND ENDED AT 5:00 PM. CONTRACTOR HAVING PROBLEMS GETTING COMPACTION. ROLLER IS INADEQUATE SIZE AND

MATERIAL IS TOO WET.
COMPACTION RAN 95.2%.

-182-

INSTRUCTIONS GIVEN OR RECEIVED AND VISITORS:
ADVISED CONTRACTOR TO GET A HEAVIER ROLLER AND TO AERATE THE BASE TO LOWER THE MOISTURE.

AREA ENGR. WAS ON PROJECT THIS AM. DISCUSSED SURFACE TREATMENT PAVING PROCEDURES AND SEASONAL LIMITATIONS FOR PAVING

CONTRACTOR WAS ADVISED THAT THE PAVING SEASON FOR ASPHALT CEMENT BITUMINOUS MAT'L ENDS NOVEMBER 1 AND THAT HE IS BEHIND SCHEDULE.

REMARKS:
JOE BROWN - TESTING MGMT WILL RECHECK COMPACTION TOMORROW

SIGNED: Earl A. Rhodes, ET II

INSTRUCTIONS FOR THE INSPECTOR'S DIARY

Under the Project Number enter the Project Number and County.

Enter the month, day and year in the DATE block.

In the WEATHER block enter a description of the weather conditions. These conditions shall be given as "clear", "partly cloudy", "cloudy", "rain", "sleet", etc. and give the times for the rain, sleet or snow.

In the TEMPERATURE block enter the ambient temperatures for A.M., Noon, and P.M.

List the contractor's personnel in charge of the project in the section titled Contractor's Representative.

List major types of equipment the contractor uses during the day in the section Contractor's Activities and Equipment. Also include a brief description of the work accomplished, the location, time contractor began and ended work, and make any observation concerning the adequacy of the contractor's work force and the operational condition of the equipment.

List any instructions you gave or received in regard to the project on that day and include any visitors in the section labeled Instructions Given or Received and Visitors.

Under the Remarks section, list anything pertaining to the project that isn't covered by the other topics.

Be certain to sign your name and give your title on the last line as is indicated.

It is not mandatory that an Inspector's Report or supporting records be submitted each day on each item in progress. Inspector's Reports should be submitted when there is a substantial amount of work to be reported, but shall be submitted at least monthly to document progress payments to the contractor.

Inspector's Reports shall be numbered consecutively either according to District-wide or area-wide system depending on the arrangements authorized by the District Engineer. Any incorrect or erroneous matter on an Inspector's Report must be crossed out instead of being erased or correction fluid used, and the correction written in the available space. The person making the correction should initial the correction.

Load Tickets

Load Tickets for items on a weight basis will be certified by a Certified Public Weigher (CPW). The Inspector shall check each ticket for proper certification and ensure that all required information is shown. Then he shall sign the first ticket of the day, with his title and initial all subsequent for the remainder of the day. If the roadway Inspector is changed during the day, the new Inspector shall sign the first ticket with his title and initial subsequent tickets. Also, you should refer to the appropriate construction manual information and the Field Construction Memo (FCMs).